THE ECONOMICS OF GRAIN STORAGE

by

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INTRODUCTION

This study is undertaken to develop a theory to be used in determining the location of wheat storage facilities. In recent years there has been a great increase in demand for such storage facilities. There has been a difference in emphasis placed on where storage facilities should be located. Examples of this difference may be found by comparing recent public statements on grain storage and storage problems.

In May 1950, the Farm Credit Administration in cooperation with the Oklahoma Agricultural Experiment Station published the results of research on the economics of grain storage.[1] A major conclusion based upon this study was that farmers cannot afford to store wheat on the farm if commercial storage facilities are available.[2]

Now compare the above with a statement made by Mr. Emmet Womer, of the Kansas Production and Marketing Administration. He states that more farm storage is needed to handle the Kansas wheat crop. According to Mr. Womer, "An increasing need for considerably more farm storage exists largely as the result of large grain crops and a sharp downward trend in some grain exports. . . Another factor necessitating more farm storage facilities is the increasingly greater opportunity for abundant crop production, resulting from wider use of soil conservation measures, improved seed varieties, better insect control, and labor saving machinery."[3]

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[1] Hall, Thomas and others. *Where and How Much Cash Grain Storage for Oklahoma Farmers*, Farm Credit administration bulletin 58, May 1950.

[2] Quoted directly the conlusion is, "The average Oklahoma farmer cannot afford to use farm storage for his cash grain--even in facilities he now owns--when elevator storage is available through a nearby shipping point." Ibid., p. 47.

These statements illustrate that there is a considerable difference in emphasis on locating grain storage facilities. One agency of the United States Department of Agriculture indicates that farm storage of wheat is most desirable whereas another agency of the same federal department indicates non-farm storage to be most desirable. These differences in expressed opinion indicate that either one side or the other is in error--or perhaps neither has fully considered all aspects of the problem of the location of grain storage facilities.

It is logical to assume, therefore, that an analysis of the economics of grain storage location would be a helpful guide to those concerned with the construction of new storage facilities. This study is a step in that analysis. It begins by providing a theoretical frame of reference for studying the problems involved. Following this, a plan is proposed to be used in determining the amount of storage capacity needed at various locations and is tested with available data.

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[3] Womer, Emmet, Kansas State Committee of the Production and Marketing Administration, November 28, 1950. See also The Northwestern Miller, March 20, 1951 for a similar statement by Charles F. Brannan, secretary of agriculture for the United States.

REVIEW OF LITERATURE

History of Storage

Storage of grain has been an important practice all through history. Among the earliest civilizations to make special recognition of the grain storage problem was the Peruvian Inca civilization. They had storehouses constructed of stone which were of large capacity.[4] Another early grain storage project is recorded in the Holy Bible.[5] This concerned the storage of excess grains in ancient Egypt in preparation for distribution during the years of famine.

The most elaborate of the ancient warehouse systems was developed in ancient China. Under an early set of rules laid down by Li K'a, an ancient ruler, the government acted as an equalizing force by buying and storing excess grain from good crops and selling it to the people in seasons of famine.

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[4] Prescott, W.H., Conquest of Peru - Book I, New York, American Publishing Corporation., pp. 59-61. 1881.

[5] The Holy Bible; Genesis 41:48.

The plan was advocated for the following reasons: (1) Farmers are short-sighted and will not store grain. (2) Farmers are helpless to protect themselves against violent price fluctuations. (3) Grain is the commodity with the greatest influence on human lives. (4) Agriculture is subject to nature and may not follow supply and demand.

There were, however, several weaknesses inherent in the system which caused it to be ineffective in spite of these arguments in its favor: (1) There was no reliable source of funds with which to buy the excess production; (2) The administrative officials didn't know the 'just' price which should be paid; (3) There was too much expense and delay involved in administering the warehouses, and purchases. (4) The officials were often reluctant to part with grain in minor famines for it wasn't known what the next year would bring. (5) "During an emergency when the grain is necessarily issued, it has become dust and dirt which cannot be eaten".[6]

The literature of the Middle Ages, mercantilism, and the early industrial era carries only general references to storage of grain, and the problems related to it. Most of the efforts were concerned with price problems during panic and famine years. In these times special distribution was the problem rather than temporal distribution.

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[6] Chen, Huan-Chang. The Economic Principles of Confucius. Vol. 45, New York: Longmans, Green and Co., 1911.

The grain trade in France is typical of this period. Lack of communication and transportation, coupled with the absence of any sort of organized wholesale markets, kept the trade highly disorganized. Storage seems to have been more generally located on the farms and in the villages. Landlords and local merchants kept grain for long periods. "Much grain was stored by landlords as their receipts of rent in kind. There is no effort to find a market. The landlord waits patiently year after year till the merchants come to buy."[7]

Storage as a Marketing Function

A number of writers on marketing have analyzed the commercial motives involved in the storage of grain and the functions of storage in the marketing organization. One of those was John T. Horner, who listed two reasons why storage was necessary.[8] The first is seasonality of production, and the steady nature of consumption; the second is the time required for marketing. Due to these factors there is a time-lag between production and consumption which must be filled by the use of storage. While the product is in storage there are a number of functions which must be performed if storage is to be effective:

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[7] Usher, Abbott Payson; The History of the Grain Trade in France. Harvard Economic Studies; Harvard University Press, Cambridge, Mass. 1913, p. 77.

[8] Horner, John T; Agricultural Marketing. John Wiley and Sons, Inc. New York: 1925. pp. 49-58.

1. Storage must protect quality of the product.
2. Storage develops the quality of the product.
3. Storage allows the movement of goods in large quantities.
4. Storage makes the shifting of risk possible.
5. Storage aids in financing the ownership of the product.
6. Storage broadens the market for the product.
7. Storage regulates the flow to market and decreases price fluctuations.

Many of the same ideas are presented by Fred E. Clark in his book, Principles of Marketing.[9] Storage is called the second function of physical supply. Time and place utility of goods are indicated as important storage considerations.

Two reasons for storage are stated by Mr. Clark. First, short-time storage is necessary to correct temporary conditions of price or transportation emergency. Second, adjustment of supply and demand is necessary for products which are produced seasonally.

There are five points listed as 'the nature of storage service' which are as follows:

1. Stocks must be cared for properly.
2. Stocks must be stored at convenient points. in selecting this point, there are four conditions

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[9] Clark, Fred E., Principles of Marketing, New York, The Macmillan Co., 1942., p. 315-316.

which must be met.

a. The interests of producers, middlemen, processors, and consumers are all important.

b. Stocks need to be near financial agencies which are able to supply funds for investment in them.

c. Inspection and supervision can be more effectively accomplished on a large scale.

d. Storage should be located where merchants who buy in large quantities are congregated.

3. Stocks must be financed while in storage.

4. Storage must be controlled in order to protect the interests of all parties involved.

5. Storage has an important effect on prices.[10]

Literature on Storage and Public Policy

One of the most extensive grain storage programs of modern times was initiated under the ever-normal granary of the Agricultural Adjustment Act and related programs. This was administered by the United States Department of Agriculture of which Mr. Henry A. Wallace was then Secretary. The storage of grain, according to Mr. Wallace, was part of a five-point governmental policy which should be fundamental to a permanent program of farm legislation.

These points were outlined by Henry H. Wallace as follows:

1. Farmers are entitled to their fair share of the national income.

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[10] *Ibid.*, p. 316.

> 2. Consumers should be afforded protection against drouth, floods, and pestilence which cause abnormally high prices. Storage of reserve supplies from years of large crops for use in time of crop failure will accomplish this.
>
> 3. If consumers are given the protection of such an ever-normal granary plan, farmers should be safe-guarded against undue price declines by a system of loans supplementing their national soil conservation program.
>
> 4. Control of agricultural surpluses above the ever-normal supply is necessary to safeguard the nation's investment in loans, and to protect farmers against price collapse due to bumper yields which provide production beyond all domestic and foreign needs.
>
> 5. The present Soil Conservation Act should be continued, its operation simplified, and provision made for reduced payments to large operators on a graduate scale to promote the interest of the independent farmer.[11]

While the main points of this program are based on price supports and control of production, there is a basic assumption that surplus agricultural commodities, such as wheat and corn, can be stored and kept off the market for an indefinite period. It is also assumed that these commodities can be moved painlessly back into the normal market channels when the lean years arrive.

One of the most recent writers on the subject of grain storage is Geoffrey Shepherd. He discusses "the objectives, uses, and costs of feed grain storage" in the November 1949 issue of the Journal of Farm Economics.[12] The problem may be somewhat different for feed grains, nevertheless his discussion of objectives can safely be applied generally to all grains.

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[11] "Henry Wallace Explains the Ever-normal Granary", Literary Digest, Volume 124:13-15; November 20, 1937.

First, he discusses the ability of a storage program to protect and increase farm prices. It was pointed out that this objective is not valid because grain will, in the long run, tend to depresa farm prices when removed from storage about the same amount at it raised them when it went into storage. Thus, a program to reduce production is the only type which can raise prices over the long run.

Second, the objective of stabilizing farm prices is examined. Mr. Shepherd argues that storage should not be used to stabilize prices against variations in demand. Such variations are unpredictable; their intensity is variable; their duration is variable; and it is not possible to calculate in advance how much grain will need to be stored. From the social point of view such storage would have a bad effect on low income groups during depression periods. If storage is used to raise prices it would lead to the paradox of starvation in the midst of plenty.

A storage plan would be able to achieve the stabilization of prices against the effects of variation in supply.

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[12] Shepherd, Geoffrey. "The Objectives, Effects, and Costs of Feed Grain Storage", Journal of Farm Economics; Volume 31, November, 1949.

It can put the excess stocks into storage in years of large crops, and take them out in years of small crops. According to Mr. Shepherd's analysis, this goal can be achieved. However, difficulty would arise if production were consistently above consumption.

A more complete analysis of storage theory and motives of storage is discusses by D. Gale Johnson in his book, "Foreward Prices in Agriculture". These motives are considered first in the light of private storage, and the same points are viewed from the public storage viewpoint. The first consideration is called the convenience motive. Such practices as the buying of large stocks of wheat for milling, and the holding of wheat on the farm until a more convenient marketing date, are examples.

The second motive for holding stocks is labeled the contingency motive. An example of this type is the holding of a reserve supply in case of an unforeseen financial reverse which may warrant the need for ready cash.

The third motive is the speculative one. Stocks may be increased if a price rise is anticipated and vice versa. This is quite important in stimulating private storage, but is not very significant in controlling excessive marketing volume during periods of very low prices. The speculative motive is the only one of the three that could be considered as capable of affording incentive enough to level consumption, and to reduce production in the face of a prospective price decline.

Experience has indicated that reduction of production and leveling of consumption are not achieved by private speculative holding of grain. It is often argued that farm production remains high through periods of low price due to inflexible production costs. This is an important factor, but Johnson feels that there are also other factors which make it difficult for farmers to reduce marketing and production. The first of these is the nature of price anticipation on the part of farmers, the second is the nature of the capital market, and the third is the insecure financial position of most farmers which causes inability to make adjustments by storing grains. Regarding these points, the farmer sees no incentive to store if he anticipates a prolonged low price, and the lack of reserve funds and inadequate financing prohibits farmers from storing for the relatively short periods needed to over-ride a short-time price decline.

When storage is considered from the public viewpoint the same motives are in force. According to Mr. Johnson, the convenience motive will have much the same role as in private storage. The effects of the other two, contingency and speculation, will be different. "In public storage policy the speculative element will be based wholly upon changes in supply, except as the slow, moderate, long-run changes in demand are taken into consideration."[13] This is different from the profit-taking motive of private speculation, and allows the holding of grain stocks in the face of short-run declines in price.

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[13] Johnson, Gale; Foreward Prices in Agriculture, Chicago The University of Chicago Press, 1947.

The contingency value is not widely considered in private storage, whereas this factor can have strong influence when considered as part of a wisely administered public storage program. Increased stability of livestock feeding is cited as one of the principle gains from the stability of stocks through storage. Stockmen are more likely to start a long-time business if they are certain of the availsbility of feed grains.

"The amount of storage when expectations are uncertain depends upon the marginal gain from stocks and the marginal cost of storage."[14] The marginal gain from storage was considered by Johnson as the "increase in total satisfaction derived by stabilizing the consumption of a given supply of goods in time."[15] The marginal cost of storage would need to be based on the past pattern of output for the crop. From this series an average storage period could be computed and the marginal cost of storage calculated for the average period.

Resource costs such as interest on funds invested, depreciation, and deterioration charges should be included in storage costs. However, for purposes of analysis, changes in monetary values of stocks are assumed by Johnson to have no effect.

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[14] Ibid., p. 165.
[15] Ibid., p. 165.

The location of storage atocks are considered briefly by Johnson. "In general, the largest stocks should be carried in the heaviest producing areas."[16] Other considerations and costs, the regional distribution of crops, and relative amount of fluctuations in production in different areas. It is suggested that the Great Plains states would gain a great deal of stability if wheat storage capacity was expanded. More livestock feeding is advocated for stability of agriculture, and the wide fluctuations in grain production of this region make expanded storage essential if livestock feeding is to become a permanent part of the economy.

One of the most recent publications on wheat storage is a bulletin for Oklahoma farmers published in May, 1950. In this bulletin were published the results of a survey of storage needs for Oklahoma farmers.

The conclusions of the bulletin indicate that the costs of using farm storage are greater than the cost of using elevator storage. Thus if storage is available at elevators the farmer cannot afford to use farm storage.

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[16] *Ibid.*, p. 165.

On the other hand, storage facilities of a permanent nature should not be built in excess of the capacity needed for average storage requirements. This indicates that there is the possibility that farmers will have to provide some of their own storage in years of larger than average crops.[17]

METHODS OF PROCEDURE

In this study the theory of grain storage location was developed by deductive analysis. The theory was applied to wheat, and a model developed which includes the determination of the variable factors which act to determine the total supply of wheat which should be stored. These factors are presented in a series of implicit equations to establish their relationship to the total supply of wheat.

The supply of wheat for storage was then allocated among three storage locations--terminal, country elevator, and farm. The allocation was made according to the relationship of the three storage locations to the fundamental factors of production variability and the performance of storage services. On the basis of these two factors, the relative contributions of the different storage points was determined.

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[17] Hall, Thomas and others, *op*. *cit*., p. 47.

The decision on the portion of the wheat crop which should be stored at each location is presented in a series of implicit equations. Those equations are presented first in this form to show the relationships which exist as determined by deduction. The equations are then applied to the best secondary data available.

FACTORS WHICH AFFECT WHEAT STORAGE NEEDS

The general outline for the total amount of wheat storage space needed is presented in Figs. 1 and 2. The factors which determine the total supply of wheat to be stored are traced in Fig. 1, and the allocation of the total supply of wheat to the different storage locations is traced in Fig. 2.

Total Supply of Wheat

Referring first to Fig. 1, let Y be the total supply of wheat; let C be the total annual average carryover; and let A be the normal crop. Then tho equation for the total annual supply of wheat becomes:[18]

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[18] Imports of wheat into the United States were not considered for the following reasons: (1) The United States is usually a net exporter. (2) The United States imports most wheat in seasons when the production peak is past.

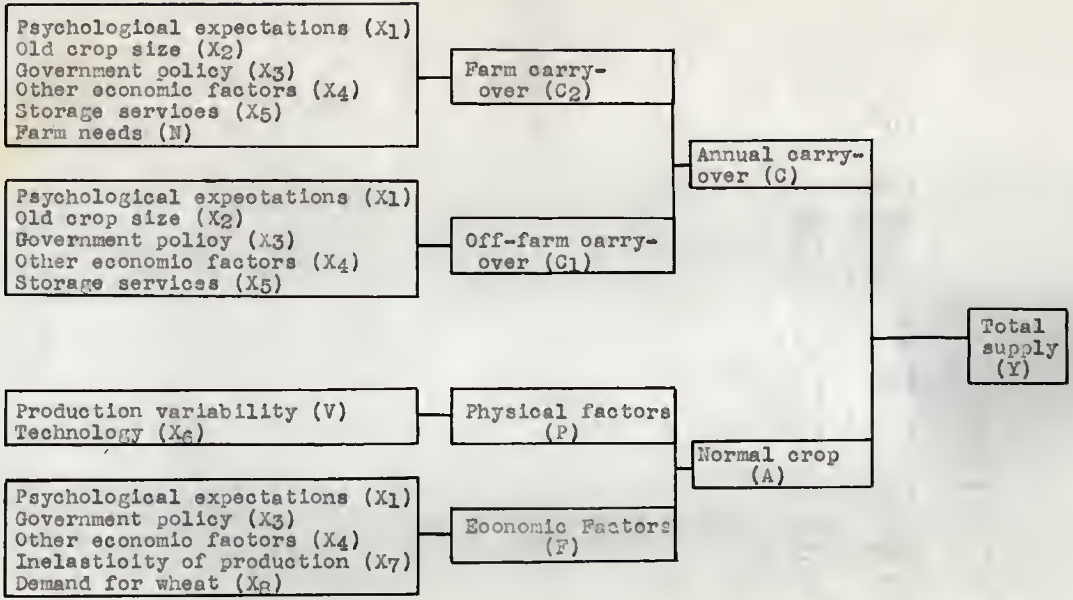
Psychological expectations (X_1)
Old crop size (X_2)
Government policy (X_3)
Other economic factors (X_4)
Storage services (X_5)
Farm needs (N)
Farm carry-over (C_2)
Psychological expectations (X_1)
Old crop size (X_2)
Government policy (X_3)
Other economic factors (X_4)
Storage services (X_5)
Off-farm carry-over (C_1)
Annual carry-over (C)
Total supply (Y)
Production variability (V)
Technology (X_6)
Physical factors (P)
Normal crop (A)
Psychological expectations (X_1)
Government policy (X_3)
Other economic factors (X_4)
Inelasticity of production (X_7)
Demand for wheat (X_8)
Economic Factors (F)

Fig. 1. Factors which determine the total supply of wheat.

$$(1) \quad Y = A + C.$$

The annual average carryover (C) is made up of two terms representing different lots of wheat. As shown in Fig. 1 these are off-farm carryover (C_1) and, farm carryover (C_2). Thus the equation for total average carryover is:

$$(2) \quad C = C_1 + C_2.$$

The absolute value of C_1 is dependent upon the following group of independent variables. Let X_1 be the psychological expectations concerning the future; let X_2 be the siz3 of the old crop; let X_3 be the government policy affecting wheat storage; let X_4 be the other economic factors; let X_5 be the storage services; and let f be the functional relationship among these variable factors. Then the equation for off-farm carryover is:

$$(3) \quad C_1 = f(X_1, X_2, X_3, X_4, X_5).$$

The absolute value of C_2 is dependent upon the same group of variables as those affecting C_1 with the addition of the farm needs for wheat. Let N be the farm needs for wheat. Then the equation for farm carryover is:

$$(4) \quad C_2 = f(X_1, X_2, X_3, X_4, X_5, N).$$

The normal crop. The normal crop (A) is made up of two terms representing different sets of influences. As shown in Fig. 1 these are the physical factors (P) and the economic factors (F). Thus the equation for the normal crop is:

$$(5) \quad A = f(P, F).$$

The absolute value of P is dependent upon two independent variables. These are production variability (V) and the effects of technology on wheat production. Let X_6 be the effect of technology. Then the equation for the physical factors acting on the normal crop is:

(6) $P = f(V, X_6)$.

The absolute value of F is dependent upon many of the same variables which affect C_1 and C_2. These are X_1, X_3, and X_4. In addition, there are two other variables which affect the value of F. These are the inelasticity of production, and the demand for wheat. Let X_7 be the inelasticity of of production, and X_8 be the demand for wheat. Then the equation for the economic factors affecting the normal crop is:

(7) $F = f(X_1, X_3, X_4, X_7, X_8)$.

The total supply of wheat can be determined with the series of equations defined above and outlined in Fig. 1. They are listed below as follows:

(1) $Y = A + C$.

(2) $C = C_1 + C_2$.

(3) $C_1 = f(X_1, X_2, X_3, X_4, X_5)$.

(4) $C_2 = f(X_1, X_2, X_3, X_4, X_5, N)$.

(5) $A = f(P, F)$.

(6) $P = f(V, X_6)$.

(7) $F = f(X_1, X_3, X_4, X_7, X_8)$.

Total Storage Space

Referring now to Fig. 2, let S be the total storage space required for wheat. This is equal to the total supply of wheat (Y) as determined in Fig. 1; hence:

$$(1)\quad Y = S.$$[19]

Let T be the terminal storage capacity; let E be the country elevator storage capacity; and let O be the farm storage capacity. Then the equation for total storage space required for wheat is:

$$(2)\quad S = T + E + O.$$

Terminal capacity. Terminal storage capacity (T) is determined by two quantities. One is the harvest movement of wheat to the terminals, and the other is the off-farm carryover of wheat.[20] Let H be this harvest movement of wheat to the terminals and C_1 be the off-farm carryover. Then terminal capacity is:

$$(3)\quad T = H + C_1.$$

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[19] The value of S includes some farm storage of a dual-purpose nature which is temporary only as far as wheat storage use is concerned.

[20] The value of H may need to include wheat which moves out of temporary farm storage to terminals during the first few months after harvest. This should be considered in the application of the equations to actual conditions. The assumption used here is useful as a first approximation, and is applicable to the available data.

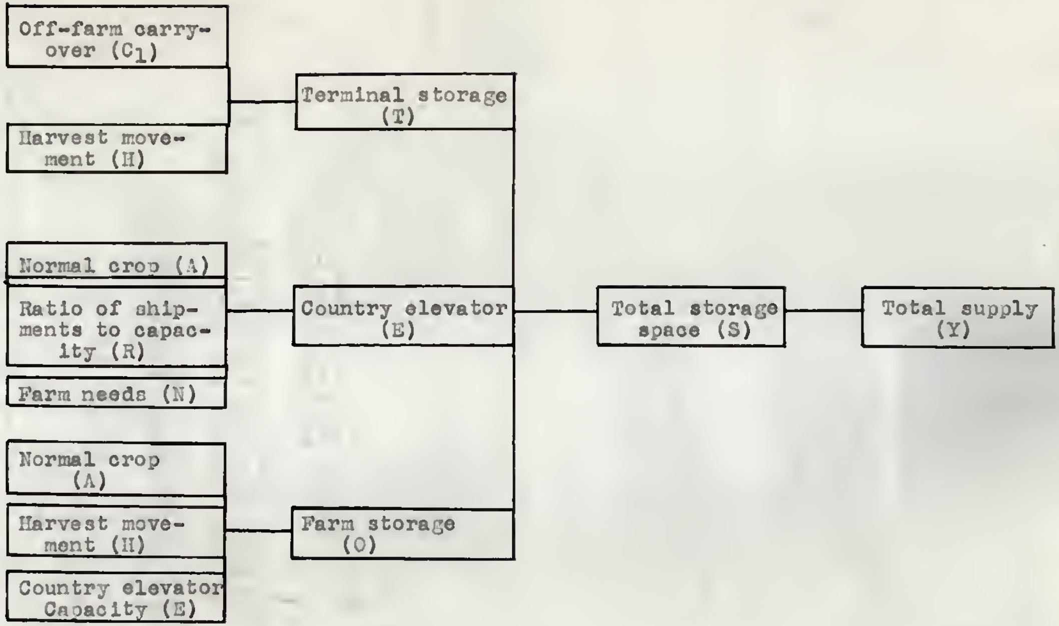

Fig. 2. The allocation of the total supply of wheat along the different locations.

Country Elevator Capacity. The country elevator storage capacity (E) is determined by three different factors. Let A be the normal crop; let N be the farm needs for wheat which will stay on the farm; and let R be the ratio of annual volume of wheat handled to total storage capacity.[21] Then the country elevator equation becomes:

$$(4)\quad E = R(A - N).$$

Farm Storage Capacity. The farm storage equation is determined by four factors which have been defined previously. These are the normal crop (A); the size of the harvest movement to terminals (H); the amount of country elevator space (E); and the farm carryover (C_2). The equation for farm storage capacity is:

$$(5)\quad O = (A + C_2) - (H + E).$$

The total supply of wheat can thus be allocated to the different locations by using the equations given above and outlined in Fig. 2. They are listed below as follows:

$$(1)\quad Y = S.$$

$$(2)\quad S = T + E + O.$$

$$(3)\quad T = H + C_1.$$

$$(4)\quad E = R(A - N).$$

$$(5)\quad O = (A + C_2) - (H + E).$$

The two groups of equations which have been presented in this section are the basis of the wheat storage theory.

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[21] The size of R may be affected by varying costs of storage and the amount of wheat available for storage in the country elevator.

The symbols assigned in this section will be used throughout the remainder of the treatise when reference is made to any of the factors which have been defined in the preceding discussion.

DEFINITION OF THE MAJOR STORAGE LOCATIONS

Terminal storage is that storage space which specializes in the secondary storage of wheat. The word 'secondary' indicates that the bulk of the wheat is not moved directly from the farm, but has passed through a country elevator. The interior collection points, commonly known as subterminals, are included in the terminal category if they are situated so that they normally receive wheat in large quantities from an area of at least several counties in size.

The country elevator is a storage facility which specializes in receiving wheat from farmers, in concentration or assembly of this wheat into carload lots, and in the resale or shipment of this wheat without processing. Country elevator storage includes, of course, all storage space which is located at country elevators.

Farm storage is that storage facility which is the property of the farm operator or the farm owner. This storage must be located either on the farm or at such a point that shipment to the terminal is possible only by loading the wheat with the facilities of a country elevator or a similar arrangement. Farm storage includes all types of permanent and semi-permanent facilities which are used to store wheat.

DETERMINING THE STORAGE CAPACITY FOR WHEAT

At the Terminal

The terminal elevator location (T) is best adapted to handling the bulk of off-farm carryover (C_1) because of its superior ability to perform the storage services. In addition, the terminal is the least affected by local variations in production.

The top limit on terminal storage capacity is determined by the amount of wheat which the transportation system is able to move to the terminals during the harvest rush. This limit (H) is imposed since the wheat which cannot move to terminal storage during this period must have local storage which is adequate to maintain the quality of the grain. Therefore this wheat does not need terminal space until some of the terminally stored wheat is moved into consumption channels.

Therefore, the equation for total amount of storage capacity needed at the terminal is:

$$T = C_1 + H.$$

At the Country Elevator

Due to their location, country elevators will handle all of the wheat crop which is marketed through commercial channels with the exception of a minor portion which is delievered by truck directly to flour mills or terminal storage. Thus, the problem of determining the proper amount of storage space at the country elevator is a matter of determining the most effective ratio of total storage capacity to total annual volume of wheat handled.[22] This ratio (R) is a key factor in finding the efficient size for the country elevator storage unit.

The aggregate volume of wheat marketed through the country elevator can be found by subtracting the average farm needs (N) for feed on or near the farm where produced, seed, and home use from the long-time average crop (A). Thus the volume of wheat marketed through the country elevator can be stated as being equal to $(A - N)$. Since the elevator must have an adequate annual turnover; the total country elevator capacity can be determined by the equation:

$$E = R(A - N).$$

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[22] The annual ratio of total sales to capacity, the amount of wheat held in country elevator storage, and the length of the storage period for such wheat would affect the optimum size of R. There may also be differences in costs of operating different elevators which would be a factor in determining the size of R.

On the Farm

The storage space on the farm (O) must be suffident to meet the average farm needs (N) and the farm carryover (C_2). The farmer will also need to provide space for that portion of the average wheat crop which cannot be moved from the farm during the harvest season.[23] This will be equal to the average crop (A) plus the average farm carryover (C_2) minus the harvest movement of wheat to terminals (H), and the capacity of the country elevator (E). Thus the equation for farm storage capacity is:

$$O = (C_2 + A) - (H + E).$$

RELATION BETWEEN TRANSPORTATION AND STORAGE

The top limit on terminal storage capacity tends to be set by the ability of the transportation system to move the wheat during harvest.

> Disregarding for the moment other influences on the capacity required, the grain that can be moved from country elevator to sub-terminal or terminal elevator during the harvest season would tend to put a top limit on the capacity needed at sub-terminal or terminal positions.[24]

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[23] This means that farmers will need to provide some short-term storage for a few months. This may be accomplished by the use of dual-purpose buildings such as machine sheds or cattle sheds for temporary wheat storage. These are "temporary" for wheat use, but are permanent farm buildings.

[24] Hall, Thomas and others, op. cit., p. 35.

Thus the volume of harvest movement of wheat to terminals (H) is one of the key factors in determining the allocation of storage space among the various storage locations. The value of H may also need to include wheat which moves from dual-purpose farm storage or from country elevators after the initial harvest movement. The volume of this expansion in terminal capacity would depend upon the relative costs at the different locations, and upon the efficiency of the different locations in performance of the storage services.

At the present time, the demand for railroad cars far exceeds the supply. This condition has existed for several years in varying degrees of intensity, and has resulted in the construction of country elevator and farm storage space. The current difficulty is not necessarily a permanent one. Therefore the current value of H is not be be taken as a fixed factor in the equation, but should be considered as subject to change.

VARIABILITY IN PRODUCTION

The effects of weather can result in extreme variations in wheat production from one year to another. There is, however, much greater stability of production over a wide geographical area than is true of a limited one. Thus, the volume of grain stored in terminal elevators is not as greatly affected by these fluctuations in production as is the country elevator or farm. This permits the operation of a more stable business at the terminal location, and results in lower cost per unit and greater efficiency.

The problem of variability can be illustrated by referring to the production variability in Thomas, Ford, and Saline counties as compared to the whole state of Kansas. To compare annual production to the long-time average the thirty-year average production for these areas was calculated. This average was then divided into the annual production. This gives a percentage figure which may be called an index of production variability.[25] This index is shown in Table 1.

The data in Table 1 illustrate an important characteristic of winter wheat production. It is noted that the western Kansas counties are very erratic in their production from year to year. Since this variation is characteristic of most of the region, it illustrates the difficulty which would be encountered in locating sufficient storage at the local shipping point.

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[25] Any series of years could be used to work out this variability index. The one used is simple and serves to illustrate the point.

Table 1. Index of variability of wheat production for three Kansas counties and for the state of Kansas.[1] (average production for 1920-1949= 100)

Year	Thomas county index	Ford county index	Saline county index	Kansas index
1920	129	52	103	95
1921	62	73	68	88
1922	98	41	104	82
1923	60	14	69	55
1924	78	141	113	103
1925	84	58	35	53
1926	43	190	109	101
1927	17	54	124	75
1928	80	200	124	114
1929	104	185	79	102
1930	186	97	107	122
1931	144	220	134	165
1932	60	53	86	79
1933	10	10	82	44
1934	27	19	68	55
1935	6	13	52	42
1936	32	40	120	79
1937	39	24	117	104
1938	73	48	81	100
1939	39	20	58	75
1940	48	24	152	83
1941	103	136	124	114
1942	254	212	97	131
1943	167	66	84	95
1944	85	247	104	123
1945	225	126	108	136
1946	202	148	126	140
1947	312	208	123	188
1948	142	173	138	152
1949	91	108	113	103

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[1] Production information from The Biennial Reports of the Kansas State Board of Agriculture.

THE GENERAL SERVICES OF WHEAT STORAGE FACILITIES

There are eight general services which must be performed by the storage facilities:

The Quality Should Be Maintained

The most important storage service is the maintenance of quality. In order to fulfill this service, the storage plant must protect the grain from the weather. This means that the bins must be water-tight and should keep out snow. Protection from fire is another factor, and demands attention. Protection from infestation by weevil and rodents is another very important factor. This is one of the most important and most serious of all quality problems affecting the wheat crop. Rodent damage seems to be of somewhat lesser importance, but the weevil loss over the state is serious. Weevil infestation is a problem largely associated with storage; therefore the storage facilities must be adapted to the job of controlling weevil in the wheat. Otherwise they are not adequate to carry out the function of quality maintenance.

Certain crop years are characterized by wheat which has a high moisture content. In such years it is very easy to let the wheat decline in quality. Care must be taken to see that the grain is turned and properly conditioned. This is important in the control of such quality factors as heat damage and total damage. The storage facility must have equipment to handle the wheat and prevent this type of damage.

A final quality problem which is very important in grain marketing is the maintenance of high quality through proper segregation of wheats by variety, protein content, and grade. It is important to millers that they know the protein content, variety, and grade of the wheat which they mill into flour. Therefore it is a necessary part of the storage function that it be possible for these quality separations to be made.

Storage Facilities Should Be Convenient to Transportation

The second general characteristic required of wheat storage is convenience to transportation facilities. This is a very obvious requirement which can cause difficulty if transportation facilities shift after the grain elevator has been built. The removal of a railroad line would leave a grain elevator with no adequate outlet to the terminal markets. This possibility must be considered in the planning of storage expansion.

A transportation problem of even greater importance is that of ready availability to any desired market. In order to achieve ideal marketability of the stored grain, it should be in a position to move to any market, over any transportation system and on the shortest possible notice.

Storage Should Be Convenient for Inspection and Supervision

It has been demonstrated by the history of wheat marketing that there must be warehouse and elevator inspection and supervision. In order to facilitate inspection the storage plant should be conveniently located. Large, well-kept elevators are easier to supervise, and are most satisfactory for effective public warehousing of wheat. Therefore, wheat storage should be located at points which are convenient for inspection. The expense of inspection increases greatly as the geographic distribution of the licensed warehouses is increased. Warehouses which store for public account should be concentrated near large markets.

Storage Facilities Should Be Available to a Market Center

The goal of all storage is to move wheat, except that stored on the farm for use as feed and seed, into commercial outlets for human food, livestock feed, or industrial uses.

To achieve this end, the wheat should be stored at points which make it readily accessible to the widest possible market. The largest amount of wheat should be available to the greatest number of buyers to assure the best market for that wheat. This means that large quantities of wheat should be available to the trade in order to supply the best grain for any particular buyers' needs.

This does not imply that all surplus wheat has to be stored "next door" to the processing plant. On the contrary, if the market center is well informed about the supply of wheat, if it has good relations with the country buyers, and can get good service from the transportation system, it is possible for the best movement to be from a country elevator direct to the processor. In such cases the terminal agency could act as an agent in getting buyer and seller together.

The essential thing is that the wheat be stored at points where its quantity and quality is well-known to the trade, and that it is near an efficient, adequate transportation system.

Storage Facilities Should Serve the Individual Interests of Producer, Processor, Middleman, and Consumer

The general requirement that storage should serve all the best interests of these four groups is obviously an impossible one. For instance, it would be possible for enough storage space to be built at a country point to hold all of the wheat grown in the market area. However, the profitability of such a storage plant would be questionable even in above average years, and certainly would not pay in years of below average crops. Yet this would be in the interests of the individual farmer who is concerned with getting his wheat harvested and into an elevator with a minimum of loss.

It is apparent that a compromise must be worked out to satisfy these divergent individual interests. At this point all of the special interests will be pointed out and discussed. The compromise between them is left for discussion at a later point.

Producer Interests. A primary need of the producer is a continuous market for his wheat. Wheat is a seasonal specialty crop which is produced in a specialized wheat farming region. Many farmers are highly dependent upon the sale of their wheat to finance the farming operation and furnish the family living. Therefore, the farmer needs a continuous market in order that he may sell all or part of his crop at any time. Adequate storage facilities will aid in providing this continuous market.

The individual farmer also needs a market outlet which will handle all of the grain which he produces. Ideally, all wheat would be of top quality but this is not the actual case. Rain, dry weather, weevil, leaky bins, and weed seeds are a few of the factors which lower the quality of wheat which the farmer offers on the market. This lower quality wheat is more difficult to store on the farm than is good wheat. Therefore, the producer markets them more quickly, and it is to the interest of the farmer and the trade in general that this poorer quality wheat be utilized in some manner. The importance of storage is even greater, and the problem of location is even more acute with the inferior grades. Inferior wheat often requires special equipment for handling during storage. Care must be exercised in its location in order that it be efficiently utilized.

The producer has other special interests which are important in storage construction. These are the need for a seed supply, a reserve carry-over, wheat for home use, and space to store wheat for livestock feed.

The seed and carry-over supplies are rather constant and are practically always located on the producer's farm. The feed supply presents a different problem. Wheat is ordinarily not fed to livestock in large quantities due to the price advantage of the feed grains. There are some years when this situation changes, and the feeding of wheat becomes relatively more important. In these years the use of wheat as livestock feed is important and would be a factor in determining the amount of storage needed on the farm, especially if fed on the farm where produced. In addition, some wheat is fed to chickens directly from the bin regardless of price.

The principal producer needs for storage may be summarized by stating that storage space should be provided in adequate quantity at locations which will provide a continuous market regardless of quality or quantity. In addition, the individual producer needs to provide good storage bins which are adequate to hold his own seed, a carry-over of wheat, and space for any wheat which is to be fed locally.

Processor Interest. The processors' interests are quite similar to those of the producer. The need for a continuous market is also of importance to the processor, since he must be able to buy any quality or quantity of wheat at any time. The miller of a "family" flour has different requirements from those of a miller who sells "bakers" flour. The processor of commercial feeds and the industrial alcohol producer may be able to use still other grades of wheat. It is obvious, therefore, that processors in general need a large and continuous supply of all types of wheat. This wheat should be stored so that it will be readily available and stored at the lowest possible cost.

Merchandiser Interest. The merchandiser or grain merchant is primarily a handler of papers evidencing title to wheat. It is his function to bridge the gap between the producer and the processor. He fills the gap between the time the farmer wishes to sell his wheat and the time that the miller or processor wishes to buy that wheat.

Storage space which serves the middleman's interest must meet several requirements. It must be adequate to handle wheat in large volume; it must be located so that it can be used near full capacity during most of the year. It must also be able to handle grain of several qualities at the same time.

Most of the capital invested in wheat during the time it is in the middleman's hands is either investment capital borrowed from banks or speculative capital. This brings up a point which must be considered when selecting the location for middleman's storage. This refers to the definite concentrations of such capital which exists near larger cities. This tends to draw the commercial storage plants to these points unless the storage point has certain advantages which will draw the capital to it.

There is one type of middleman who must locate near the great speculative markets. This is the storage elevator operator who makes a business of storing grain for others. These men function solely as caretakers of the grain and allow speculators to assume the risks of ownership.

Consumer Interest. The principal consumer interest in storage is the effect of storage on price stability and cost to the consumer. Therefore, it is to the consumer's interest for storage facilities to be located at points which minimize storage costs, maximize utilization of all qualities of wheat, and make the most efficient use of transportation facilities.

The effective maintenance of quality in the storage of carry-over stocks is another point which is of concern to consumers. It is often advantageous to producers and others if carry-over of excess wheat is not large or efficient. However, from the viewpoint of consumers there is always a loss when carry-over grain is not properly utilized.

Storage Must Be Located at Points of Capital Concentration

There are a number of other reasons why storage facilities must have large amounts of capital available. First, it takes a huge amount of money to finance wheat while in storage. For example on February 24, 1951, there was approximately 28.3 million bushels of wheat in storage in Kansas City.[26] Figured at the daily low price for number 2 dark, hard wheat of $2.41 per bushel, this meant an investment in wheat of over 68 million dollars. Since much of this money has to be borrowed from commercial banks it would require the presonce of large banking service to meet this demand.

In addition, the speculative nature of wheat ownership demands special banking service in order to assure sound banking practice. Most grain exchanges require that the traders who buy and sell both cash wheat and futures contracts have a certain minimum capital to back up their transactions. This adds stability and reduces the risk involved.

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[26] Data from: Kansas City Grain Market Review, February 24, 1951.

The investment in plant facilities for storage is also very heavy. At present costs, the most commonly quoted figure is one dollar of construction cost per bushel of space. This means that a 100,000 bushel elevator requires an investment of 100 thousand dollars. Loans of this amount would not be as readily available at points away from the money centers. It is possible to obtain such credit by going to the city bank, but problems of administering and servicing increase the cost of the loan until the borrower located in the country is at a disadvantage relative to a borrower who is building his elevator near the financial center.

This does not imply that storage will not be built at a point which has definite advantages as a storage center but is not one of the great money centers. In such cases the capital for storage construction will migrate to this particular storage location.

Storage of Wheat Stabilizes Supply and Demand

Wheat storage at strategic points can aid in stabilizing the supply and demand for wheat and smooths out the fluctuations in price which would otherwise exist. The supply of wheat becomes available in a relatively short period of time. Although no statistical evidence is available it is quite evident that storage plays a large part in overcoming the price variations which would certainly result if all wheat had to be consumed at harvest. It is also likely that the demand factors act in a more deliberate and efficient manner due to the presence of storage facilities. This is probably the result of a greater feeling of confidence which prevails in the market when there is known to be an adequate supply of wheat.

An important service which acts to balance supply and demand is the presence of an accurate market reporting service which makes the location and size of wheat in storage common knowledge. The accuracy of such information is related in a practical way to wheat storage location. For instance, there is greater accuracy in statistical enumeration of wheat which is stored in a conveniently located terminal elevator than if this same wheat is scattered in a hundred different farm bins.

Storage is Necessary to Implement Government Programs

Storage of wheat under various governmental control programs is one of the common motives for wheat storage. As is pointed out in the review of literature on the subject, this phase has received more attention from writers and theoretical analysts than any other phase of the storage problem. The reasons for this are obvious, since government policies have come to play such an important part in wheat storage. Such plans as the "ever-normal" granary and the present price support program make extensive use of storage. The stocks of wheat owned by the Commodity Credit Corporation and wheat which is under loan have been very important factors in the wheat marketing picture. At the present time the government is probably one of the major influences in the wheat market, and has been especially important in causing storage expansion. Therefore, implementing government programs is an important service of the storage facilities.

Terminal Storage and the Eight Services

Maintain Quality. The first service of terminal storage must be the effective maintenance of quality. The primary points to be considered are protection from weather, moisture, insects, heat damage, fire loss, and the separation and segregation of different qualities of grain.

The terminal storage plant has many advantages which enable it to do an excellent job of maintaining wheat quality. Chief among them are the economies of large scale operation. Larger elevators and a greater volume of grain at terminals make it possible to install grain driers and special cleaning apparatus at these points. Such equipment can be utilized most effectively at the terminal because it is located at a point which handles grain from a wide area, and is assured of large quantities of such grain every year. This cuts the per unit charges against this equipment to a minimum. Other normal conditioning operations which can be performed at a lower cost in large volume are fumigation, insect control, and the blending of wheats into useable mixes.

It is also possible that better construction is possible at the terminal than is accomplished at other points. This is not necessarily a characteristic of terminal storage, but is due to the efficiencies of scale associated with terminal storage.

Efficient use of labor, especially management, is another important factor in the maintenance of wheat quality at terminal points. Accurate figures would be difficult to obtain, but it is generally accepted in the trade that one of the greatest reasons for poor quality maintenance at non-terminal points is the low rate of pay for managers of non-terminal elevators. This results in lowering in the level of management ability which is secured, and increases the risk of storage loss.

Convenience to Transportation. Terminal facilities naturally fulfill this requirement. They are in larger cities and are usually served by more than one rail line and may have additional transportation outlets on waterways, lakes, and rivers. Their location at strategic transportation crossroads adds to the usefulness of the space located at these points.

Inspection and Supervision. Terminal grain storage is generally easier to supervise and inspect by government warehouse supervisors than is warehouse space located at outlying country points. The costs of inspection sre lower when the warehouse examiner can inspect several lsrge elevators at a sihgle location than when it is necessry to travel a long distance to inspect the same capacity located at many different points. More frequent inspections are also possible when less time and money must be spent on travel. The supervision of warehouses which are licensed as delivery points for wheat to fulfill futures contracts is another advantage of terminal elevator space.

Assure a Wide Msrket. Grain at a terminal hss an advantage in marketability. Due to their locstion at the market center, terminal grain stocks are immediately available for delivery to grain handlers and processors. This allows the owners of these stocks to take advantage of short-term market fluctuations which change too rapidly for country shippers. There is also a larger number of potential buyers at the terminal. This tends to improve the competitive selling position of terminally stored grain.

The breadth of msrket at the terminal is due to the greater variety of grain available at that point. Because the terminsl is located at the transportation crossroads, there is a much greater variety of wheat availsble at the terminal than at local country points. This means that buyers hsve easy access to all types of grain which are required to fill their needs.

Meeting Special Interests. The primary function of terminal storage in serving the producers' interest is an indirect one. Terminal storage facilities are often used indirectly by producers through the medium of warehouse receipts, which are issued by local elevators on grain. This is a means whereby farmer-owned wheat can be stored in the terminal. Another indirect service to producers is that terminal storage helps provide producers with a continuous market for their wheat. Without terminal facilities to handle wheat carry-over stocks, farmers would not be able to sell wheat at any time they may choose.

Terminal storage is essential to the processor interests. Mills, feed manufacturers, and industrial users of wheat need to be able to rely on a steady supply of considerable volume in order to assure stability and continuity of business. The established terminal elevator firm is looked upon as a reliable source for wheat of a given grade and quality. The presence of the terminal elevator is convenient for the processor because he is not required to scour the producing region for the required type of wheat. He can rely instead on the specialized ability and services of the terminal grain movement.

In addition to the grain storage service of the terminal merchant, there is need for a considerable volume of grain stored on the premises of the processing merchant. The processor needs this storage space in order to plan his operations on the basis of a known quantity and quality of wheat. It is also profitable at times to buy large supplies of wheat when prices are low and the grain is available at a more favorable basis. This lends price support to the market at a time when support is needed.

The grain merchant or middleman is the principal owner of terminal grain storage facilities. Such storage is essential to the type of operation performed by the middleman who takes title to grain with expectation of profit on resale. There are other grain buyers who speculate in such grain but do not own any space. Since they hire the storage space from terminal elevator operators it is also essential to them. Often the operators of these storage elevators do not assume any risks of ownership but simply opefate a warehouse elevator. There are a large number of combinations possible, but the important point is that storage space for the actual grain must be available at the terminal in order that the middleman may operate effectively.

The principal consumer interest which is served by wheat storage is that of stabilizing the price level. It also provides a steady supply of finished products for consumption. The price stabilizing service of storage is discussed at a later point.

Ease of Financing Terminal Storage. Wheat in terminal storage has certain advantages over wheat stored at other points. The volume of capital investment in grain is very great. Since such capital is usually borrowed it requires the services of rather large, specialized banking facilities. Such banking services are more likely to be available at terminal locations.

This does not mean that terminal space will be limited to financial centers. It means rather that large-scale banking services will be made available for investment in wheat and wheat storage at terminals in preference to local country elevators which do not have terminal advantages.

Adjustment of Supply and Demand. Terminal grain storage is no more effective in achieving long-time adjustment of supply to demand than storage located at country and farm storage points. However, the higher liquidity of terminal stocks would help eliminate short-term market fluctuation in cases where the farm and country-stored wheat would be unable to move rapidly enough to correct the situation.

Another market service of terminal storage is that it facilitates accurate market reporting of available wheat stocks. This helps eliminate the possibilities of price manipulations and "scare" shortages such as were possible before the development of terminal markets.

Because a terminal is locatod at a point which receives grain from a wide producing area, it is possible for the market to draw supplies from an area which is extensive enough to avoid crop variations due to local conditions. This is the problem of local variability in production which was previously discussed.

The long-run stability of supply at the terminal improves the stability of wheat prices. It accomplishes this partly because an organized market is made possible. A Board of Trade and other formal market organizations take time to become established and are not likely to become a part of the market equipment if the wheat supplies on hand are not adequate to provide a steady market. The long-run result of such market organizations is the converse of this. The presence of a reliable market tonds to draw traders and trading opportunities to it. Thus the immediate influence of all supply and demand factors are most likely to be felt at an established terminal market, and adequate storage at the terminal is essential to the provision of an adequate supply.

Implementing Government Programs. Terminal storage has the same services to offer government programs that are available to other interests. The high level of quality maintenance and availability to transportation to export outlets are perhaps the major advantages of terminal storage in implementing government storage programs.

If the government policy is concerned with surplus stocks of wheat, the terminal may be too far removed from the producing region to perform the best service at harvest time. However, the terminals have a place since they can be used to handle old-crop carry-over supplies, and can thus relieve the pressure on farm and country elevator storage in advance of the new-wheat crop. This seems to be one of the major services of terminal storage under a government system of price supports and storage of wheat.

The Country Elevator and the Eight Services

The country elevator performs an essential service when it gathers small lots of wheat into larger lots which can be most efficiently handled by the marketing system. In connection with this service there must be a certain amount of storage space.

Quality Maintenance. The maintenance of quality at the country elevator is an individual matter. Success depends more upon the knowledge, ability, and attitude of the country operator than upon any other factor. The effective storage of wheat is an exacting task. This is especially true if the grain is not in good condition when received from farmers. It is possible for country elevators to do an excellent job in quality maintenance, and this is usually not a serious problem.

Poor elevator construction and poor maintenance of buildings is often found at country shipping points. This is often the result of the operation of a business which does not handle the volume of wheat necessary to pay the costs of maintenance. If the lack of profit is due to inefficient management, it may be remedied. However, if the storage facilities of the local shipping point are overbuilt it may be best to discontinue the operation.

One of the greatest obstacles to quality maintenance at a country elevator lies in its limited capacity to segregate the wheat according to quality factors. Most country elevators are limited in the size and number of their bins. Hence, they often have difficulty in making adequate separations of the wheat on the basis of quality variation.

Due to the country elevator location at outlying points, they draw most of the grain from a rather limited area. Very little winter wheat moves to a country elevator from more than 20 miles away, and most of it comes from much closer to the elevator. The net result of this restricted supply area is that all the wheat in an area is subject to many of the same weather and crop conditions. If the harvest is unusually wet in a certain area the local elevators of the region will be receiving a steady run of wet wheat. This wheat will be difficult to keep in local storage because of limited handling facilities and the absence of dry wheat to mix with the damp grain. Therefore, they will have to move the grain to terminal storage as soon as possible and leave the country elevator storage space empty to await the next crop.

Convenience to Transportation. The country elevator is usually located with reasonable convenience to transportation facilities. They must be convenient to one railroad and often have access to two railroads. This is the maximum convenience that can be expected due to the country elevator's primary function as a concentration point for wheat. The type of transportation outlet should be seriously considered in locating an elevator storage at country points. It is logical to demand better transportation service and a more certain outlet for a large country elevator of 200,000 bushels of storage capacity than for a 5,000 bushel house which handles and stores very small quantities of grain.

The recent problem of railcar shortages has been a strong argument for the construction of more country elevator space. This type of storage seems to work out very well if the country elevator can remain in the position of a warehouse agency. This has been the case in recent years due to the government sponsored program of loans through the Commodity Credit Corporation, but could change if the type of government policy was changed.

Under this program the title to the grain has been in the name of either the farmer or the Commodity Credit Corporation. (In any event the Commodity Credit Corporation has borne the risk of any price change.) The problem is quite different when viewed in the light of conditions which would exist without this program. It seems very likely that the number of farmers who would pay elevator storage charges on their wheat and bear the risk of price decline would be substantially lower than the present number who store on the basis of a purchase agreement and loan guarantees. This observation is based on the fact that the present system allows the farmer to receive most of the cash value of his crop very soon after harvest and to benefit from late price change without risk. As many farmers need the money from their crop soon after harvest, it seems probably that much of the grain now stored would be sold to meet operating expense if there was no loan program.

Wheat sales by farmers at harvest would shift the storage charges and price risk to the elevator operator. Since most of the country elevators do not have the funds to finance wheat in storage, they will not be able to hold the wheat in the country even though the space for such storage is available. Therefore, the need for country elevator space would decline.

Inspection and Supervision of Country Elevator Storage. This is a relatively unimportant consideration and is mainly a problem of added expense in providing adequate warehouse supervision. This factor would, however, be important due to the difficulties which may be encountered in securing legislative appropriations to maintain inspection agencies. Observation of actual conditions would lead one to the conclusion that all such agencies operate more efficiently and effectively if they are staffed with a few well paid personnel. Such groups can be more easily supervised and the positions will be filled with better qualified personnel.

Availability to the Market. The marketability is variable in the case of wheat stored in country elevators. The geographical location of the elevator and type of transportation available are important. The aggressiveness and initiative of the individual operator are also important factors in determining market availability.

A local buyer has a wide range of opportunities in selecting the time and place of sale. A large number of buyers is one of the essential characteristics of a wide market. A large number of buyers is not actually present at the country shipping point, but it is possible for the local operator to maintain contact with a number of terminal buyers. Good coverage of market information is a means of widening the market of an individual country buyer. By securing a number of dependable sources of market information, the country buyer is in a better position to obtain the best price for his wheat.

In the physical sense wheat stored in the country is not as available to the market as wheat in terminal storage. Time consumed in transit and slower communication with country points make it more difficult to secure wheat from country storage on short notice. This keeps country stored wheat from being as marketable as terminally stored wheat.

Transportation uncertainties are also a problem. Boxcar shortages due to strikes, or diversion of rail cars to other uses may cause difficulty in making delivery of country stored wheat. There have been periods when country elevator operators could not contact a sale because of this uncertainty.

Serving Special Interest. There should be enough storage at the country elevator to provide a continuous market for wheat. If a constant market is to be maintained this is a factor of primary importance. The country buyer should be able to take all qualities and quantities of wheat when the farmers in his territory wish to sell this wheat.

An exception to this rule will often exist at harvest time since it is impractical for country elevators to take all of the grain offered during the harvest period in seasons of heavy production. This is one of the limitations which must be placed on the country elevator.

In serving the producers' interests the local elevator should be conveniently located. With the widespread use of modern farm trucks, the optimum distance from farm to market is greater than when a team and wagon was used to haul wheat to market. However, the elevator must still be at the hub of a good system of farm to market roads.

It is often in the producers interest to have a choice of elevators available for handling his grain. This helps eliminate problems of monopoly and price discrimination which may otherwise arise. Such competition could be provided by more than one elevator at the shipping point or by an alternative shipping point within a reasonable distance.

It should be pointed out that the need for competition does not mean that there must be excess capacity at the country shipping point, but that the space available would tend to provide better service if it were divided among several competing elevators.

The country elevators provide an essential service to processors because they are the local concentration points which collect wheat from the farmer. This is the primary function of such storage as far as most processors are concerned. In special cases where an interior mill is located near an individual country shipping station, it is advantageous for the mill to be able to collect and store a large amount of locally produced wheat. In such cases there is a definite processor gain from country storage.

Another type of country elevator storage which serves the processor interests is that which is owned and operated by a milling company. Known as "line" elevators, these are used as country buying stations to supply the wheat for the milling and processing operations of the parent organization.

The grain merchants achieve the greatest gain from the country elevator because of its use as a concentration point. There are also many country elevators which are used by grain merchants in the same manner as the "line" elevators previously discussed under mill ownership. Some of this grain is stored at the country point, but the bulk is shipped to the terminal for storage or sale. This traces back to the existing variability in production of wheat.

The consumer gains from country elevators storage in direct proportion to its contribution to an efficient marketing system. The ability of the country elevator to hold grain in storage until salable lots are collected and then move this grain to the terminals is of primary importance to the consumer. This is part of the means of achieving the most efficient market system.

Availability of Financing. One problem of the country elevator is to secure capital for investment in the wheat. Most local operators are not able to keep a large portion of their funds tied up in stored grain, since the amount of money involved is large. For example, 25,000 bushels of wheat in a local elevator, valued at two dollars per bushel, would mean an investment of 50 thousand dollars. At 6 per cent interest on the investment this amount of stored grain would cost $1500 over a 6 month period.

There would also be risks of price fluctuations. The proper use of a futures hedge can protect the operator against ordinary price fluctuations, however, if the wheat commands a premium on the market this premium is not protected by a hedge. In this case the elevator operator is forced to bear the price risk without any real protection from the hedge.

Many local banks are unable to make large loans on wheat in storage because the loans are too large. Banker interest may be hard to arouse in storage wheat, since it is somewhat speculative in nature. Thus loans for storage are quite different from loans which allow elevator operators to finance their regular buying operations by means of discounted bills of lading.

The conclusion is that there is often too much market risk at the country points. The holders of risk capital tend to locate at terminals where the risks are minimized. Thus there is little speculative holding of wheat at country elevators.

The situation is somewhat the same for capital investment in storage facilities, Current estimates place the cost of a storage plant at about one dollar per bushel of space.[27] Thus a 50,000 bushel elevator would mean an investment of 50 thousand dollars. To gain a minimum return of two per cent on this investment would mean that storage returns must be $1,000 per year in order to pay interest on the investment. If we assume that he receives one cent per bushel per month storage, and keeps the house filled all year the total returns would be $6,000 per year. Using the current buying margin of five cents per bushel to cover operating expenses, interest, and profits would leave $3,500 to apply on the repayment of a loan. This means that fourteen years would be required to pay off a 100 per cent loan under conditions of 100 per cent filled capacity on a year round basis.

However, this is the most favorable outlook possible. If the elevator were used at only 50 per cent capacity the time required to repay the loan would double. Thus the amount of storage capacities in relation to the normal volume of grain handled is very important in determining the soundness of investment in elevator facilities.

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[27] This is an approximation based on informal talks with elevator operators. A lower (or higher) cost would reduce (or raise) the time needed to repay loans for such construction.

Supply and Demand Adjustment. The country elevator occupies a key place in the adjustment of supply and demand for wheat. For example, if the price of wheat rises significantly, it will cause a number of farmers to sell wheat which had been in farm storage. The country elevator buys this wheat and ships it to the terminal market. Thus is an essential link in the chain from the producer to the central market. This service of the country elevators makes it necessary that storage capacity should always be available at the country elevator.

Country elevator storage is not so well adapted to meeting short-run supply and demand adjustments. This is due to the time-lag which exists in shipping wheat from the country elevator to the terminal. This factor is robbed of some of its importance by the use of various types of contract sales. Such contracts use a discount to cover the buyer for the added price risk which he assumes while the wheat is in transit.

It may be concluded that wheat which is stored in a country elevator possesses a somewhat lower degree of sensitivity to demand conditions which are in inverse ratio to the distance between the elevator and the terminal market. The elevator closer to the terminal market has a smaller disadvantage than an elevator which is further from the terminal.

Implementing Government Programs. Most of the government programs concerning wheat have used the country elevator to fulfill two functions. First, it acts as a concentration point for the wheat involved in the government program. Second, there has been an increasing tendency for the country elevator to supply storage for the government owned stocks of wheat.

Total country elevator capacity has been steadily increasing, but the capacity available on July 1 for the new crop wheat has been declining in Kansas. For example, the total bulk storage in Kansas increased from 142 million bushels in 1948 to 174 million bushels in 1950. This was an increase of over 32 million bushels in commercial storage capacity. On the other hand, the space available for the new crop on June 1, has declined from 100 million bushels in 1948 to 71 million bushels in 1950 or a decline of over 29 million bushels.[28] Much of this trend has been due to the storage of increasingly large stocks of wheat owned by the Commodity Credit Corporation.

The problem of providing adequate rail transportation at harvest is currently serious. Until this problem is solved the location of space at country elevator points to handle the government wheat is a better location than the terminal elevator.

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[28] Data supplied by the Kansas State Agricultural Statistician, Topeka, Kansas.

Farm Storage and the Eight Services

Quality maintenance of wheat in farm storage is a very complex problem. The effectiveness of quality maintenance varies widely from year to year, and the variation between farmers is even greater. The factor of individual responsibility is most important in affecting quality maintenance on the farm.

Regular treatment for weevil, good maintenance of bins, control of rodents, and careful selection of wheat to be stored are the most important considerations in good quality maintenance. The success of the farmer in maintaining his stored wheat in good quality depends upon the application of these principles.

Much wheat is damaged in farm storage through failure to observe these fundamental considerations. The combine has undoubtedly contributed to the problem of quality maintenance. Weevil are probably encouraged by the binning of combine-harvested grain which has too high moisture content for storage. Binning of damp wheat can cause the grain to heat which results in heat damage and germ-damaged kernels. In conclusion it seems there is room for improvement on the average farm, nevertheless the quality loss in farm storage is not necessarily a dominant factor, but is one which can be solved with proper attention.

Convenience to Transportation. Farm storage should be convenient to the available transportation. Good farm to market roads are an important factor in making farm storage usable to the best advantage. This is an unavoidable weakness of much farm storage since there are times when the roads are impassable. This makes it impossible for the farmer to move the wheat in order to take advantage of a favorable market. This problem varies with the individual farm and cannot be generalized.

There is another phase of transportation convenience which may outweigh this inconvenience in selling. At harvest time there is a large amount of wheat available to country elevators. The pressure often becomes so acute that trucks stand in line for hours before being unloaded, and they sometimes find the elevator filled so that no more wheat can be accepted. Under such conditions the farmer has to provide farm storage for the wheat. Such storage may be either permanent or temporary, but he must provide some type of storage.

Another transportation problem causes many farmers to store wheat on the farm at harvest. This problem is the relative efficiency of storage locations as they affect the harvesting operation. The distance to town may be too great for trucks to haul the wheat directly to the elevator and return to the field in time to receive the next dump of wheat, or it may be that too much time is spent by waiting to unload at the elevator. Both delays will reduce the speed of the harvest and raise the harvesting expense. These problems make many farmers feel that it is more efficient to provide wheat storage on the farm than it is to haul directly to the elevator.

Inspection and Supervision. This factor is not of particular significance to the farm storage problem. There is little chance that it would have importance, since each farmer is storing only his own wheat. The exception to this would be storage of government stocks under some type of price support program.

Market Availability. The market availability of farm stored wheat is not as great as at other points. Individual initiative on the part of the farmer is necessary in assuring the best outlet for his wheat. The use which the farmer makes of market information is an important factor in determining returns to the farmer. Competition between country elevators is also an important influence upon the price received by farmers.

From the standpoint of physical availability, farm stored wheat is the most inaccessible of all storage stocks. Trsnsportation delays and the time-lag which accompanies the receipt of trade information by every farmer makes the movement of farm stored wheat relatively slow process. It must be borne in mind, however, that only a part of the total crop need be on the open market at any one time. Therefore, this lower degree of market availability is not too important.

Serving Special Interests. The basic producer needs which can only be satisfied by farm storage of wheat are space for seed, feed, emergency carry-over, and home use. These needs are basic but there are other factors which make it necessary for the producers to store wheat in excess of these needs. Most important is the transportation problem at harvest time which was previously considered. Quality variation between farms may be another factor which would allow an individual farmer to gain from storing wheat on the farm. In the past farmers with high protein wheat have occasionally been able to have a protein test made and then sell the wheat at a better price.

The principal processor gain from farm storage is the manner in which it restricts the harvest flow of wheat. Farm storage helps to smooth out the flow, and provides processors with a steady supply of wheat. The quality deterioration which often takes place on the farm is one of the drawbacks of farm storage. Millers are often critical of the lack of attention paid to quality in farm storage. This is the most serious processor criticism of farm storage.

Farm storage is most important to the grain merchant because of the control which it exerts on the flow of wheat from the farm. The presence of adequate farm storage relieves the initial harvest-time pressure on the middleman, and allows him to make better use of his storage equipment, labor and sales force.

Farm storage is of greatest importance to consumers because it helps control the fluctuations in market supply. This is accomplished by restricting the flow at harvest. Thus the amount of farm storage which will result in the most efficient marketing system is of greatest interest to the consumer.

Availability of Capital. The problem of financing wheat which is stored on the farm is important in limiting the amount of wheat held in farm storage. In the absence of a government loan program, the financial situation of the farm operator is a strong factor in determining how much grain he can store on the farm. The unavailability of bank credit has been a factor in limiting the farm storage of wheat. This factor should not provide too great an obstacle over a long period of years as it should be possible to develop specialized credit facilities which would meet the needs of the farmer.

The cost of constructing adequate storage facilities is another financial barrier to farm storage of wheat. In times of very high construction costs, this is an important factor. However, the costs of construction at all points will usually move in the same direction, thus farm storage construction would be no more objectionable in high-cost periods than any other type of storage construction. Therefore, the high-cost objection becomes a matter of individual decision. If farm storage is preferable (in all other respects) to storage at other points, and the farmer is in a financial position to make the investment, it should be constructed.

The farmer must guard against the danger of overbuilding storage space. The amount of permanent space which will be adequate depends to a great extent upon the stability of wheat production in the area. Space for a normal crop is all that can profitably be provided and the exact amount of space will vary with the individual farm.

Supply and Demand Adjustment. Farm storage of wheat is useful to the marketing system in the adjustment of supply to the demand for wheat. A market glut is avoided through the use of storage on thousands of individual farms. The seasonality of wheat production makes it impossible for the marketing machinery to absorb all of this wheat at harvest, and the transportation syetem is unable to provide transportation for all of the wheat being harvested. Therefore farm storage is very important for holding the wheat until transportation is available. Because of the short-term storage required for most wheat, it behooves the farmer to provide this space at the least possible cost. The use of dual-purpose farm buildings is one possible means of meeting this need.

Implementing Government Programs. Farm storage space has been used in the past for storage of wheat under government control. Most of this has been wheat upon which loans have been made by tho government, but the title to the wheat is still in the hands of the farmers. When title passes to the government the wheat is removed from farmer owned storage.

The aims of government policy can vary greatly, but the usual goals of price supports, or building up a commodity reserve, can be partially carried out by farm storage. There is no need to move this wheat away from the producing region immediately after harvest, thus farm storago of government wheat can help relieve the pressure upon transportation. In this way farm storage would seem to have a place. However, the long run problems of maintaining quality, and inspecting and supervising farm stored wheat would tend to make the use of such storage an inefficient practice.

Synthesis of the Three Locations

The three storage locations have been considered at length, and relative strengths and weakness of all have been pointed out. The remaining task is to pick out the storage point (terminal, country elevator, and farm) which can do the best job of performing the eight storage services.

Terminal Storage. The terminal storage elevator has a number of significant advantages in respect to efficiency in performing the storage services. Quality can be more effectively maintained at the terminal than at the other points. Statistical evidence is lacking, but the grain trade has more confidence in the ability of the terminal warehouseman to maintain quality than it has in the country elevator operator or the farmer. There are a number of reasons for this which have already been covered in detail but are listed briefly here.

(1) The terminal has more efficient conditioning equipment.

(2) The terminal elevator can handle stored wheat at a lower per unit cost, due to larger volume of wheat and economies of scale.

(3) Storage of wheat is a technical operation which requires careful supervision and frequent inspection by skilled workmen.

(4) The terminal storage company can more easily afford the expert supervision necessary to maintain quality.

(5) Terminal storage is best equiped to segregate wheat according to grades.

The over-all transportability of wheat in terminal storage is superior to that of the other points. Since terminals are located at the hub of a number of rail lines, the terminal has a ready outlet to all consuming centers.

The terminal elevator is also most convenient for inspection and supervision as required to carry out the provisions of state warehousing laws. The widespread use of marketing by grade also makes it necessary that wheat be inspected, and the terminal is the best point for such inspection.

Wheat in terminal storage has a strong advantage of marketability over all other positions. This is due to a combination of the following factors.

(1) Superior quality maintenance enhances the marketability of the wheat.

(2) Most wheat stored at a terminal is stored on a graded basis and can be sold with greater certainty.

(3) The terminal is closer to the processing center. This makes wheat at this point more readily available to supply an urgent short-term demand.

(4) The number of buyers at the terminals is greater and provides a better market.

The usefulness of terminal storage in serving the special interests of producers, processors, middlemen, and consumers is a matter of degree, and varies considerably with the special interests of the individual being considered. Storage of wheat is necessary at all three points if the best interests of all are to be served. Terminal wheat storage is necessary to the special interests of both processors and middlemen. The processor needs the specialized mixing, speculation, and availability of supply which is provided by terminal storage, and the middlemen who perform these special functions will naturally need terminal storage space.

The terminal location also has an advantage in the availability of capital for investment in wheat and in the storage facilities. The large volume of short-term credit necessary to finance wheat ownership is usually more readily available at the terminal. The reasons for the preference for terminal storage by the banking business are summarized in the following statement.[29]

> A request by a large cooperative marketing group for financing to hold wheat in country storage was refused by Chicago banks. Grounds for this refusal were as follows:

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[29] Essroger, C.V., The Function of the Country and City Banker in Marketing Grain. One of a series of talks on "Grain and Its Marketing" prepared by the Association of Grain Commission Merchants, Chicago, Illinois, February 1, 1934.

(1) The Chicago banks were not familiar with the warehousing laws of the several states.

(2) The banks were already indirectly financing much of the wheat through terminal houses.

(3) These terminal houses were necessarily better risks than the country houses. This was especially true from the insurance and security standpoint.

(4) It might be physically impossible to move country stored wheat to market in large volume.

(5) The wheat was not in a position to be fully hedged.

Terminal storage is also the best position at which to store grain so as to stabilize short-run supply and demand. In the long-run the total effect of supply and demand would balance out. However, weather, transportation, and psychological conditions of the market can be such that wheat from country points could not move to the market rapidly enough to balance the short-run supply and demand for wheat.

These are the principal storage services which are best served by terminal wheat storage. The eight general storage services are all fulfilled in part by the use of terminal storage. In the interests of an efficient marketing system a large portion of the grain storage should be located at the terminals. However, there are some services which can be accomplished by use of storage at other points. The next step is to consider these services and the reasons why they can better be accomplished at the other locations.

Country Elevator Storage. The ability of the country elevator to maintain quality is the first service to be examined in relation to terminal and farm storage. Quality can be maintained satisfactorily in a country elevator. The primary controlling factors are the carefulness of the operator, the quality of the local wheat crop, and the condition of the elevator building. If all three are at a high level, there should be no fear concerning the maintenance of the quality of the wheat.

It is one of the limitations of elevator storage that one or all of these factors may not be of top quality. Poor elevator condition and poor operator responsibility are often due to limits on business size which are imposed by the volume of wheat handled. Many country elevator operators are not highly paid, thus a man who is a good manager can better his income by moving to some other position. The small volume of business also often makes it difficult to maintain the physical plant in a state of good repair.

The solution to this difficulty might be the expansion in the size of the country elevator so that it would be a more efficient storage unit. This expansion would be useful up to a point where the local elevator is still able to achieve a large enough turnover to make the business profitable. The expansion would bring a number of problems which must be carefully considered. The first problem is the quality of the local crop. The area served by a country elevator is usually limited so that a wet harvest, or disease infestation will affect a large portion of the crop handled by any individual elevator. When such seasons occur, it is often impossible to keep the wheat in country elevator storage for long periods. Since the price of this wheat is low relative to that of good wheat, the storage charges for the same operations are relatively higher than for good wheat, and the total cost is also increased because of extra handling. This makes it difficult to store such wheat economically at the country elevator.

The greatest service of country elevator storage is that of concentrating wheat into carload lots and placing it on the transportation network. The country elevator has an indispensible place in the performance this service. The essential nature of this service imposes a bottom limit on the size of any country elevator, and the number of elevators need to be limited so that each receives enough wheat for a profitable annual turnover of wheat.

The country elevators can serve some of the special interests of producers, processors, merchants, and consumers. The constant market afforded by the country elevator is probably its greatest service to wheat producers. Another service which can be effectively performed is that of wheat storage for the farmer. This is no monopoly of the country elevator since the same service can be provided by a terminal elevator acting through the local elevator. However, many farmers tend to prefer that the wheat be in local storage.

The principal processor interest served by country elevator storage is the collection of wheat into convenient sized lots and shipping it to the market center or to the processing plant. Country elevator space also helps relieve the market pressure of the newly harvested crop.

Serving the middlemens' interest with country elevator storage will vary considerably with the nature of the service performed. Country elevator storage is, of course, essential to the interests of the grain buyers who operate the country elevators. The service to middlemen who perform other functions such as speculation, commission selling, and merchandising is the same as that provided the processor.

The consumer interest in the country elevator is much the same as the consumer interest in the other locations. The principal consumer service of country elevator storage is to help provide an orderly, efficient marketing service.

Adjustment of supply and demand for wheat is also aided by country elevator storage of wheat. The country elevator has a definite part to play in providing long-run adjustment since the country elevator is the point where the market demand for wheat and the primary source of supply are brought together.

Farm Storage. Farm storage has the most difficulty in maintaining the quality of wheat. However, maintenance of quality is possible if the basic rules of good storage practice are followed. These are:

(1) Wheat should be protected from the weather.

(2) Wheat should have proper moisture content if it is placed in farm storage.

(3) Care should be taken to keep from mixing wheat of different qualities.

(4) Treatment for weevil should be prompt and adequate.

If these basic rules are followed, there is no reason why the farmer cannot do a good job of maintaining wheat quality in farm storage.

Farm storage has its greatest advantage in serving the best interests of producers, processors, consumers, and middlemen. The principal service to producers is providing the farmer with space to store a reserve for seed, feed, home use and emergency carry-over. This amount of space is the minimum necessary for farm storage.

The second service to producers is an outgrowth of the modern mechanized harvest. The speed of wheat harvest releases a flood of grain in a few days' time, and it is impractical to expect the wheat marketing system to absorb the flow immediately. Therefore, some wheat needs to be held in farm storage until the rush has subsided. The dollar advantage of storage on the farm is often difficult to show, but when the choice is between storing on the farm or doing without storage then the advantages of farm storage become evident.

The gain to merchants and processors is also evident. Due to transportation limitations and the limited capacity of handling equipment at terminals, the wheat cannot move immediately from the farm to the terminal. Therefore, farm storage is very useful in providing stability in the marketing system. This is useful to the merchants and processors because it enables them to stabilize their business operations on a year-round basis.

These limitations on storage at terminal and country elevator points make a clear case for farm storage of a sizeable portion of the wheat crop. The risks of storage by farmers may be such that farmers would like to transfer them; however, the demand side of the market (processors and middlemen) cannot be expected to bear all of this risk. Thus, the producer must expect to bear a portion of the ownership risks of the wheat crop.

In summarizing the three points of storage, we may say that the terminal has these points in its favor (1) superior quality maintenance, (2) ease of inspection and supervision, (3) satisfaction of certain special interests of producers, processors, consumers, and middlemen, (4) greatest availability to sources of investment credit, and (5) performance of certain essential functions in the adjustment of supply and demand.

The country elevator is superior as a concentration point on the transportation system. It supplies the requirements of certain special interests of producers and middlemen. Finally, it is a vital link in supply and demand adjustment.

Farm storage provides its best service in holding the harvest rush of wheat off the market until the market facilities are able to handle it. This is essential in serving to balance supply and demand in the most efficient manner. Space must be available for feed, seed, home use, and reserve carry-over.

The final decision on location of government owned or controlled wheat rests on slightly different grounds than those discussed above. Tho main difference is that the marketability of this wheat is not as important. This makes maintenance of quality the first consideration, and as has been pointed out, this can be achieved at all three locations if proper precautions are observed. However, the economies of scale would give an advantage to large storage units whether located at terminals or at country shipping points. It is also important that these elevator facilities are not confused with elevator space which is erected for commercial grain handling purposes.

APPLICATION OF THE STORAGE EQUATION TO THE AGGREGATE UNITED STATES WHEAT CROP

The economic model for storage location as presented in Fig. 2 shows the general relationship between the various storage locations. We will now test this model on data for the United States wheat crop for the 20-year period from 1926 to 1947. These data are presented to show the annual amounts of total storage capacity needed as determined by applying the equations.

The Total Storage Equation

The total storage needed is determined by the equation $S = A + C$. (This can also be stated $S = T + E + O$.) Table 2 shows the annual amounts of total storage needed in the United States as determined by this equation. This calculation indicates that the lower limit on total storage capacity needed would have been 772 million bushels in 1936, and the maximum storage capacity needed would have been 1,600 million bushels in 1942. The average total capacity for the 20-year period was 1,146 million bushels.

Permanent facilities, based upon these calculations for an average year, would have been used to 80 per cent capacity in 13 of the 20 years and in 14 of the 20 years the United States would have had enough total storage to handle

Table 2. Total storage equation applied to the United States wheat crop for 1928-1947.

Year	Carryover stocks[2]			Total production[3] (A)	(A + C)
	On-farm (C_2)	Off-farm (C_1)	Total (C)		
			Thousands of bushels		
1928	19,588	92,784	112,372	914,373	1,026,745
1929	45,106	183,267	228,373	824,183	1,052,556
1930	60,216	228,663	288,879	886,522	1,175,401
1931	37,867	275,421	313,288	941,540	1,254,828
1932	93,769	281,704	375,473	756,307	1,131,780
1933	82,882	295,057	377,939	552,215	930,154
1934	62,516	211,790	274,306	526,052	800,358
1935	44,339	102,369	146,708	628,227	774,935
1936	43,988	97,700	141,688	629,880	771,568
1937	21,851	80,626	102,477	873,914	976,391
1938	58,857	94,250	153,107	919,913	1,073,020
1939	88,016	161,999	250,015	741,210	991,225
1940	79,572	200,149	279,721	814,646	1,094,367
1941	86,675	298,058	384,733	941,970	1,326,703
1942	162,722	468,053	630,775	969,381	1,600,156
1943	189,574	429,323	618,897	843,813	1,462,710
1944	103,622	212,933	316,555	1,060,111	1,376,666
1945	87,703	191,477	279,180	1,108,224	1,387,404
1946	41,606	58,482	100,088	1,153,046	1,253,134
1947[1]	40,477	43,336	83,813	1,367,186	1,450,999
Average	72,547	200,372	272,919	872,636	1,145,555

[1] Preliminary.

[2] Calculated from Agricultural Statistics--1938, table 12, and Agricultural Statistics--1948, table 15.

[3] The Wheat Situation, Bureau of Agricultural Economics; U.S. Department of Agriculture, January 1951, p. 20, and March 1937, p. 24.

all of the wheat crop. If we assume that the farmers of the United States are capable of absorbing a ten per cent excess over average production, the deficit would have been serious in only 5 of the 20 years. The obvious conclusion, therefore, is that more storage space is needed once in every four years than would be provided under the conditions of the equation based on average production for the years from 1926 to 1947.[30]

The Terminal Equation

We now will apply the terminal storage equation to this historical series to ascertain the requirements for storage facilities of this type. An approximation of the harvest movement of United States wheat for the 20-year period was secured from data on monthly marketings of wheat by farmers for July and August. The annual needs for terminal storage based on the equation ($T = C_1 + H$) are shown in Table 3. The top limit may be set by the maximum figure of 660 million bushels required in 1942, and the minimum can be placed at the 307 million bushels required in 1935. The 20-year average of terminal storage space required is 470 million bushels. The average value of T, would be adequate in 10 of the 20 years for which

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[30] Any series of years may be used in the equation, and any type of adjustments for trends in production may be used in this equation. The average was used since it serves to illustrate the method with a minimum amount of complications.

Table 3. Terminal storage equation applied to the United States wheat crop for 1928-1947. (000 bu.)

Year	Off-farm[2] (C_1)	Harvest[3] sales(H)	$(C_1 + H)$
1928	92,784	286,607	379,391
1929	183,267	323,618	506,885
1930	228,663	296,268	524,931
1931	275,421	308,349	583,770
1932	281,704	202,751	484,455
1933	295,057	164,717	459,774
1934	211,790	164,898	376,688
1935	102,369	204,298	306,667
1936	97,700	232,899	330,599
1937	80,626	310,458	391,084
1938	94,250	302,076	396,326
1939	161,999	210,466	372,465
1940	200,149	225,148	425,297
1941	298,058	283,167	581,225
1942	468,053	191,705	659,758
1943	429,323	190,224	619,547
1944	212,933	309,415	522,348
1945	191,477	385,428	576,905
1946	58,482	321,386	379,868
1947[1]	43,336	478,668	522,004
Average	200,372	269,627	469,999

[1] Preliminary.

[2] Calculated from Agricultural Statistics--1938, Table 12, and 1948, Table 15.

[3] Calculated from Agricultural Statistics--1940, Table 10, and Feed Statistics--1950, Table 45.

records were compiled. Inspection of the data in Table 3 show that the shortage would have been serious in all of the recent years except 1946. This indicates that perhaps the figure should be revised upward to include this trend.

The Country Elevator Equation

The equation for country elevator storage $E = R(A - N)$ is tested on the same series of data. The annual needs for country elevator storage based on this equation are shown in Table 4.

It would appear that the most important value to the elevator operator is the value of the turnover ration which is represented by R. In our illustration we will use the value 1/5 to equal R. This is based on the following statement made by Green and Rucker regarding capacity turnover.

> Eighty-nine per cent of the elevators handle a volume of grain equal to 6 or more times their capacities. Therefore, a capacity turnover of 6 to 10 times was considered a reasonable standard performance over a period of years. Twenty-six per cent of the low-income elevators failed to meet the reasonable standard of six-times turnover. None of the medium income group failed to reach this standard. Only 10 per cent of the high-income group fell short of a six-times turnover, and these were large storage elevators, where wheat is held for considerable periods, so that a turnover of three to four times under such methods of operation is a reasonable standard.[31]

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[31] Green, R.M., and Rucker, V.M. Marketing Problems of Farmers Elevators in Kansas. Kansas Agric. Experience Station, Extension circular 106. December 1934,

Table 4. Country elevator storage equation applied to the United States wheat crop for 1928-1947. (000 bu.).

Year	Production[1] (A)	Farm needs[2] (N)	(A — N)	C. Elev. cap. (E)
1928	914,373	138,992	775,381	155,076
1929	824,183	142,676	681,507	136,301
1930	886,522	238,074	648,448	129,690
1931	941,540	253,776	687,764	137,553
1932	756,307	206,073	550,234	110,047
1933	552,215	147,772	404,443	80,889
1934	526,052	166,060	359,992	71,998
1935	628,227	177,372	450,855	90,171
1936	629,880	200,066	429,814	85,963
1937	873,914	212,171	661,743	132,349
1938	919,913	216,650	703,263	140,653
1939	741,210	172,899	568,311	113,662
1940	814,646	183,739	630,907	126,181
1941	941,970	176,635	765,335	153,067
1942	969,381	366,310	603,071	120,614
1943	843,813	584,526	259,287	51,857
1944	1,060,111	382,344	677,767	135,553
1945	1,108,224	379,909	728,315	145,663
1946	1,153,046	261,932	891.114	178,223
1947[3]	1,367,186	271,934	1,095,252	219,050
Average	872,636	243,996	628,640	125,728

[1,2] The Wheat Situation, Bureau of Agri. Economics; U.S. Dept. of Agri., January 1951, p. 20, & March 1937, p. 24.

[3] Preliminary.

A study made in Minnesota in 1925 determined that the average relationship of elevator capacity to volume of grain handled was 4.7 bushels handled for each bushel of elevator capacity.[32] The value of 1/5 is used merely as an approximation of this figure since no recent studies are available.

The factor A in our equation has been determined; the remaining value to be calculated to determine country elevator storage is the farm needs for feeding on the home farm, seed and home use (N). The approximate total of this value may be determined by adding the amounts used for feed and seed as shown in statistics prepared by the United States Department of Agriculture.[33]

The annual needs for country elevator storage based on the equation $[E = 1/5\ (A - N)]$ are shown in Table 4. The maximum value of E was found to be 219 million bushels required in 1947, and the minimum value of E was 72 million bushels required in 1934. The 20-year average of country elevator space required was 126 million bushels. These figures may be used as a guide in establishing the amount of total storage space needed for wheat at the country elevators in the United States.

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[32] Metzger, H., and Price, H.B. *Economic Aspects of Local Elevator Operation*. Minnesota Bulletin 251, April 1929, p. 25.

[33] This may be too high since part of the wheat fed is handled by terminal storage before it is used in commercial feeds.

The Farm Storage Equation

The farm storage equation $[O = (C_2 + A) - (H + E)]$ is also tested on the same series of years. The annual needs for farm storage based on this equation are shown in Table 5.

The maximum storage needed on farms was approximately 820 million bushels in 1942, and the minimum storage needed was approximately 352 million bushels in 1934. The 20-year average of farm storage space required was about 550 million bushels. This would have been adequate in 13 of the 20 years studied.

Summary. The storage equation has been tested on the actual data covering United States production, carryover, harvest shipments, and farm utilization of the wheat crop over a 20-year period. The maximum, minimum and average quantities at each location have been determined and are presented in Table 6.

THE STORAGE EQUATION APPLIED TO A TERMINAL

The equation for terminal storage can be illustrated by applying it to an actual terminal. The application of the equation $(T = H + C_1)$ is illustrated by using data compiled on receipts of wheat and July 1 carryover for a 20-year period at the Kansas City terminal.

Table 5. Farm storage equation applied to the United States wheat crop for 1928-1947. (000 bu.)[1]

Year	$(A + C_2)$	$(H + E)$	Farm storage (O)
1928	933,961	441,683	492,278
1929	869,289	459,919	409,370
1930	946,738	425,958	520,780
1931	979,407	445,902	533,505
1932	850,076	312,798	537,278
1933	635,097	245,606	389,491
1934	588,568	236,896	351,672
1935	672,566	294,469	378,097
1936	673,868	318,862	355,006
1937	895,765	442,807	452,958
1938	978,770	442,729	536,041
1939	829,226	324,128	505,098
1940	894,218	351,329	542,889
1941	1,028,645	436,234	592,411
1942	1,132,103	312,319	819,784
1943	1,033,387	242,081	791,306
1944	1,163,733	444,968	718,765
1945	1,195,927	531,091	664,836
1946	1,194,652	499,609	695,043
1947	1,407,663	697,718	709,945
Average	945,183	395,355	549,828

[1] Data taken from Tables 2, 3, and 4.

Table 6. Limits on wheat storage capacity needed for the United States wheat crop. (bu.)

Location	Minimum	Average	Maximum
Terminal	306,667,000	469,999,000	659,758,000
Country Elevator	71,998,000	143,180,720	219,050,000
Farm	351,672,000	601,634,000	819,784,000
Total[1]	730,337,000	1,216,513,720	1,698,592,000

[1] It should be noted that the totals for maximum and minimum do not agree with those determined by the total storage equation. This is due to 'canceling out' of extremes in the total equation.

The application of the equation to this data is presented in Table 7. On the basis of this illustration the minimum terminal needs at Kansas City for the year 1946 was approximately 31 million bushels. The maximum terminal space needed was in the year 1948 when approximately 54 million bushels of space was needed. This gives the range of terminal space at Kansas City on the basis of past records on wheat handled. The average capacity needed was approximately 45 million bushels for the 20-year period. This is probably slightly lower than the normal amount which should be constructed, but is useful as a basis of determining the exact needs.

The total terminal space actually at Kansas City in 1949 was slightly over 61 million bushels.[34] Since a large portion

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[34] The Northwestern Miller-1950, Almanack Number; the Miller Publishing Company, Minneapolis, Minnesota.

Table 7. Terminal storage equation applied to Kansas City for 1931-1950. (000 bu.)

Year	July-Aug. receipts[1]	July-Aug. shipments[1]	(H) Net receipts	(C_1) July 1 stocks[2]	Total space (C_1+H)
1931	55,045	34,051	20,994	23,757	44,751
1932	24,930	9,785	15,145	37,524	52,669
1933	14,070	6,476	7,594	36,287	43,881
1934	17,509	6,514	10,995	25,616	36,611
1935	25,789	4,720	21,069	5,567	26,636
1936	36,652	9,355	27,297	3,363	30,660
1937	63,308	15,517	47,791	1,097	48,888
1938	56,784	12,726	44,058	4,225	48,283
1939	36,960	13,659	23,301	18,970	42,271
1940	44,408	13,864	30,544	20,609	51,153
1941	32,689	9,725	22,964	22,698	45,662
1942	30,111	13,460	16,651	31,839	48,490
1943	49,101	27,508	21,593	21,550	43,143
1944	55,244	13,361	41,883	8,292	50,175
1945	64,156	18,125	46,031	7,319	53,350
1946	50,986	24,441	26,545	4,010	30,555
1947	89,568	27,763	61,805	417	62,222
1948	73,069	27,727	45,342	8,936	54,278
1949	38,747	17,806	20,941	25,634	46,575
1950	44,797	23,829	20,968	27,145	48,113
Average			28,675	16,743	45,418

[1] Compiled from the Kansas City Board of Trade Yearbooks.

[2] Compiled from the Kansas City Grain Market Review.

of this space would be used for other grains the value arrived at by using the formula does not seem unreasonable.

This illustration shows the method which can be used to apply the terminal storage equation to the needs of a particular terminal. However, in addition to the application of the equation to current data there are other decisions which must be made concerning future terminal needs. The size of the market area, the variability of wheat production within that area, and the type of competition which exists between the different terminals are important factors to consider in arriving at a decision on this question.

In addition, there are certain factors which act in the long run to cause shifts in terminal storage location. These are (1) the trend in population shifts within the county, (2) the railroad freight rate structure for wheat and flour shipments, (3) shifts in export outlets, and (4) shifts in production areas. The future is difficult to forecast but certain trends can be noted.

The Effect of Population Changes

The trends in population growth and shifts in the areas of population concentration have an important long run influence on the marketing of wheat. The marketing system with terminal markets and milling centers to the east of the production areas lies on a line from the centers of population to the center of production.

However, shifts in population concentrations and internal migration have been such that the center of population has been shifting steadily westward. Thus the outlet for an increasing amount of wheat has moved closer to the production area. The net increase in population by 1975 will be greater for the Pacific coast and the southern states than for the older areas of high total population.[35] The most rapid population increases will probably take place in the Pacific coast region, the East North Central, and the South Atlantic states. The slowest increase will be in the New England area and the West North Central states.

The possibility of Midwestern wheat moving to the Pacific coast states is not great, but there could be some movement (especially of finished products) if the population of the area expanded greatly, and the freight rates were revised. Another possible result of the expanded population of this area might be the reduction of exports from the West Coast wheat producing areas. This may leave export markets available for shipments of Kansas wheat from ports of the Gulf of Mexico to importing countries which are now served by the Pacific Coast wheat producer.

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[35] Hagood, Margret J. Prospects for Regional Distribution of the Population of the United States U.S.D.A. mimeographed release, November 1949.

The rapid population increase taking place in the southern sections of the United States should also tend to shift some Midwestern wheat to a more southerly route of distribution. These factors (coupled with local population increases) tend to increase the importance of the terminal points which are located closer to the production areas.

The Effect of Trends in Production

The past thirty years have shown a definite shift in the production centers for wheat in the United States. An article, in The Wichita Magazine, July, 1929, describes the history of the shift from the spring wheat areas to Kansas. The rapid expansion in Kansas wheat production and the general recognition of the superiority of Kansas wheat for milling purposes caused many mills to send buyers into the area in the early 1920's.

> In a general way, however, buying the wheat here and milling it elsewhere is not considered an economic practice, and the trend is to bring the mills closer to the wheat. This has been the trend since the industry began.[36]

Part of this shift was due to the decline in wheat production in the spring wheat areas. This decline resulted from the pressure for alternative land uses to produce crops which yield a higher income per acre under intensive cultivation. Another cause was probably the efficient production techniques of large scale farming which were adapted only to the Southwest.

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[36] "The Milling Industry Moves Southwest", The Wichita Magazine, Wichita: The Wichita, Kansas Chamber of Commerce. July 1929.

The expansion of production has stimulated the building of terminal elevator space at points closer to the new center of production. Kansas City is still the dominant market for Southwestern wheat, but its importance is being undermined by such places as Wichita, Hutchinson, Salina in Kansas, and Enid, Oklahoma. The increased volume of production the western areas has made it profitable to establish terminal storage closer to the producing area. This development saves time and expense in transporting the crop, and helps relieve the rail-yard congestion at harvest.

Certain observations can be made about the future of the production centers. It seems that the center of production is not likely to shift to any considerable extent because of the semi-desert nature of the land farther to the west. On the other hand, rising land values and increasing competition for land use will prohibit the shift of wheat production to eastern sections of the United States. Thus future production will continue to concentrate the present wheat belt unless production methods change.

The Effect of Size and Type of the Market Area

The limiting factors on the amount of expansion at any of the interior points are the size of the market area, the variability of production within that area, and the existing freight rate structure. The terminal markets are of the type known as buying markets. They are the markets which collect goods from the producing areas and re-ship them to the consuming and processing centers.

The ideal type of terminal market situation is illustrated by the following diagram of two markets designated as A and B. If other costs are the same at both markets and the transportation charges are the same, the line CD will mark the boundary between them because the price which they are able to offer for wheat will be equal. On the other hand, if the costs of transportation to A are greater than to B the boundary will shift to the line EF. Likewise, if the reverse

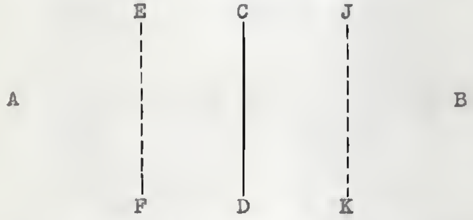

Fig. 3. Division of the market area between two markets.

is true the line JK will mark the boundary between markets. The same sort of reasoning would apply to changes in handling costs which will make one market more expensive than the other.

These rules will also apply to the outlet markets of these two terminals. If the costs of shipping from A to the outlet were greater than the costs from B to the outlet, the market for B would be enlarged to the line EF. Thus, if the two markets are to be kept on an equal basis they must have the same costs for shipping and receiving grain. If this is not true one will gain an advantage and become a relatively better place in which to store wheat.

> The flow of wheat in the United States affords a good illustration of these principles. Whether Kansas grain, for instance, moves south to the Gulf for export, or north and east to important interior markets, will depend upon the freight rate adjustment and the prices of grain in the various markets.[37]

The existing freight rate structure is important in determining the effectiveness of storage at different terminals. For example, the transportation charges from terminal A to processing center X may be 52 cents per cwt. (See Fig. 4). In contrast the rate from terminal B to X may be only 50 cents per cwt. Thus, if wheat from the producing area (Y) could move at the same rate (20 cents per cwt.) to both A and B, the preferred terminal would be B because of 2 cents lower total transportation charge from Y to X. This is because buyers located at B would be able to pay more in the country, draw the wheat to B, and ship to X for the same price as A.[38]

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[37] Locklin, D.P., Economics of Transportation, Business Publications, Inc., Chicago, 1935 p. 129.

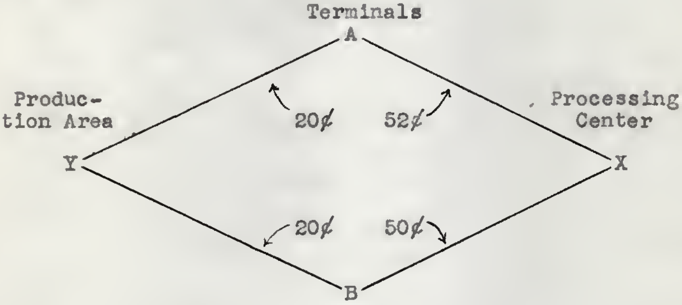

Fig. 4. The effect of freight rates on two different terminal locations, A and B.

The Effect of Other Factors

Some minor factors which could make a terminal a preferable storage location are those peculiar to the business which is contemplating expansion, or to the costs of operation at the terminal location. The type of ownership, the type of market outlets, and the relationship of the terminal firm to the country elevators of the area could have a definite effect upon the decision to build at a certain terminal. For example, a line elevator may have difficulty in drawing grain from a territory if there are a large number of successful cooperative elevators operating in that territory. Obviously this would keep certain private companies out of this area. On the other hand, it would be the ideal location for a regional cooperative to expand its terminal space.

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[38] A detailed discussion of this point may be studied in Economics of Transportation by D.P. Locklin, Chapter 24.

Another example would be a terminal house which specialized in merchandising high-quality milling wheat. If the market area under consideration was noted for production of poor milling wheat this firm may not desire to make the changes necessary to handle this wheat successfully.

There are, also, a number of relatively minor points which could cause changes in the plans of a terminal elevator company. Among them are comparative real estate costs, taxes, cost of public utilities, and the availability of labor.

In going back to the equation for terminal storage space ($T = C_1 + H$) it appears that the relationship between two terminals for the storage of wheat will rest on their differing ability to increase the value of harvest movement to terminals (H) at the expense of the other or of a third terminal. There may also be opportunity for competition among elevators to carry the bulk of the off-farm carryover wheat (C_1).

Therefore, the terminal which can assign the largest values to C_1 and H in relation to the long-time average production will be the most advantageous point for constructing new storage space.

THE STORAGE EQUATION APPLIED TO A COUNTRY ELEVATOR

The application of the country elevator equation can be illustrated with a case study of two Kansas shipping points. Shipping point Z is located in northwestern Kansas and shipping point Y is located in southwestern Kansas. These elevator locations were selected because both are served by only one railroad and are centrally located in their respective counties. This makes it possible to correlate the available county production data with the amount of wheat handled by these shipping points.

The actual carlot shipments of wheat from each point were used as the basis of determining the volume of wheat handled, (See Table 8). This should be approximately equal to the value $(A - N)$ in the equation. It was determined that the correlation coefficient of wheat shipments to county production at Z gave a value for r of .73, and the value for r at Y was .75. This figure indicates a reasonable correlation between the shipments of wheat and the county production. Thus a major part of the variation in shipments from these two points is assumed to be the result of production variability.

The annual shipments from these points was divided by the 1949 capacity of these shipping points to illustrate the variability of R (the turnover ratio) over a series of years.[39]

It was determined that 80 thousand of the 125 thousand bushels total capacity at Z could be charged to wheat use. On the same basis 188 thousand of the 225 thousand bushels total capacity at Y were allotted to wheat use.[40] Table 8 shows the results obtained when the present capacity and the calculated capacity are compared to actual wheat shipments for the twenty year period from 1929 to 1948.

It is not likely that an exactly similar series of years will again be experienced, but it does seem reasonable that the same general pattern will be repeated. It is apparent that the turnover ratio more nearly approaches 5 to 1 for the long-run period using the calculated capacity than when the actual capacity is used.

If we assume that the 5 to 1 ratio is accurate, both Z and Y have too large a capacity since Z reached this goal only two times in twenty years and Y reached this goal six times in twenty years. By comparison, when the recommended

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[39] Actual shipments of other grains are not available, Therefore it will be assumed that the same proportion of county production of corn, sorghums, and barley were handled as the proportion of wheat handled at these two points. This amount was then subtracted from the total existing capacity.

[40] This capacity is ten per cent over the 20-year average in order to approximate the normal capacity.

Table 8. The ratio of actual and calculated annual wheat shipments to the storage capacity at Z and Y.[1]

Year	Shipments[2] (Bu.)		Ratio of capacity to shipments			
	Z	Y	Z		Y	
			Actual	Calculated	Actual	Calculated
1929	186,620	1,751,040	2.33	4.44	9.31	12.97
1930	337,900	1,014,120	4.23	8.04	5.39	7.51
1931	175,280	1,957,620	2.19	4.17	10,41	14.50
1932	99,200	245,705	1.24	2.36	1.31	1.82
1933	36,720	71,070	.46	.87	.38	.53
1934	4,605	82,150	.06	.11	.44	.61
1935	1,510	36,600	.02	.04	.19	.27
1936	69,525	170,040	.87	1.65	.90	1.26
1937	34,540	101,440	.43	.82	.54	.75
1938	148,050	143,100	1.85	3.51	.76	1.06
1939	22,120	111,300	.28	.52	.59	.82
1940	33,180	456,170	.42	.79	2.43	3.38
1941	278,800	477,620	3.48	6.64	2.54	3.53
1942	287,180	393,880	3.60	6.84	2.10	2.91
1943	302,750	583,100	3.78	7.21	3.10	4.31
1944	111,800	1,097,820	1.40	2.66	5.84	8.13
1945	321,480	649,985	4.02	7.65	3.46	4.81
1946	705,200	857,325	8.81	16.79	4.56	6.35
1947	429,525	1,127,520	5.38	10.23	6.00	8.35
1948	245,660	959,750	3.07	5.84	5.11	7.11

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[1] The actual capacity is 80 thousand bushels at Z, and 188 thousand bushels at Y. The capacity calculated by using the equation for country elevator capacity ($T = 1/5(A - N)$ is 42 thousand bushels at Z, and 135 thousand bushels at Y.

[2] Data on shipments were secured from the records of the Kansas State Agricultural Statistician, Topeka, Kansas.

capacity was used the 6 to 1 ratio was reached at Z in 8 of the 20 years, and at Y in 7 of the 20 years.

This illustrates the procedure which should be adopted in testing the capacity needs of a particular shipping point. Each elevator operator would need to determine his own value for R and the volume of wheat (A — N) which he can expect to handle. The optimum value of R depends to a great extent on the fixed and variable costs of operation, and upon the amount of income which can be received from storage of wheat.

Costs of construction are an important portion of the fixed costs. This makes it necessary for the country elevator operator to guard against being over-supplied with storage capacity.

Special Problems of the Country Elevator

There is a trend in transportation which is causing a shift in the market areas of country elevators. The development of motor transportation from the farm to market has increased the distance which farmers will travel in hauling wheat to market. This has had the effect of enlarging the market area for certain elevators at the expense of other elevators. This tendency is more often noticed in the post-harvest movement of wheat. When the farmer has more time he tends to market more wheat at a shipping point which can provide services in addition to wheat buying. Commercial feeds, minerals, and gasoline are frequently sold by the elevator operator in an effort to meet this demand. However, the elevator which is located at a larger town has many advantages which are not available at the smaller shipping points.

It seems likely that the future will bring a reduction in total elevator numbers and an increase in the size of each individual elevator which remains. The trend may be illustrated by the use of a diagram (Fig. 5). The present situation is illustrated as embracing three elevators at A, B, and C.

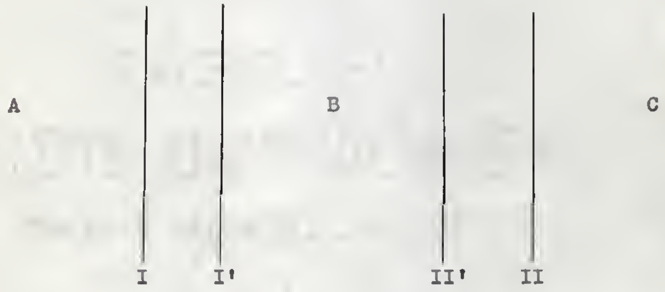

Fig. 5. Competition among local elevators.

The three elevators are serving equal markets which are bounded by the lines I and II. Assume that elevators A and C have advantages in providing supplimental services, and are served by better farm-to-market roads than those leading to B. This will cause the boundaries between the markets to shift to a new equilibrium at I' and II'. (Fig. 5) This would severely restrict the market area of elevator B and it may be forced out of existence. This trend must be considered in expanding elevator facilities, since it may be a justification for expanding the capacity of a favorably situated elevator to a greater extent than is indicated by the history of wheat receipts at that elevator.

There are a number of organizational problems which may also affect the final decision on storage expansion at a particular country shipping point. The type of organization considering expansion will have an important effect, since the attitude of the farmers toward the business may vary. For example, a cooperative may be able to expand in size in one area where it would be impossible for a line elevator to increase its size. The opposite situation may be true in another area.

The personality and reputation of the manager is another important factor. A manager who is well-liked and trusted will be much better equipped to expand his business than one who is not respected in the community. Other local differences are rent, taxes, and the available labor supply. All of these factors are important in determining the values of A and R in the general equation $E = R(A - N)$.

THE STORAGE EQUATION APPLIED TO A FARM

The general equation for farm storage $[O = (C_2 + A) - (H + E)]$ can be applied by a farmer in deciding how much storage space to provide on his farm. Each farmer has a good idea of how much wheat is usually on hand at harvest time. This makes it possible for him to establish the value of C_2 for his farm.

In the same manner, the normal crop (A) can be estimated with better accuracy when the individual farm is considered separately. One method of determining the value of A is to calculate the longtime average yield and multiply this figure by the number of acres of wheat which he expects to plant. It may be that the long-time average yield would be too low, or too high, and should be adjusted to fit changing conditions of production. This would be especially true if the farm was being cultivated with the use of better farming methods than had been used in the past. New wheat varieties and more efficient harvesting methods could also be reason for an upward revision in the yield figure used.

The harvest movement of wheat from any individual farm could vary greatly from the average of the county or from the adjoining farms. There are a large number of factors which could affect the volume of the harvest movement for any one farm.

The distance from the farm to market is one of the important factors. In general, the farmer who is located the greatest distance from the market will have the most need for storage facilities on the farm. However, there are many secondary factors which tend to cause exceptions to this general rule. Among them are the presence (or absence) of a good market road, the amount and quality of the labor force, and the quality of the grain to be stored.

The type and availability of labor is a factor which has an important influence upon the farmers decision regarding the disposition of his wheat. One farmer may be using only family labor during harvest, and may have no one who is able to drive a truck on the public highway. This farmer would feel inclined to store a larger proportion of his wheat crop on the farm.

An example of the opposite case is a situation where a farmer hires a 'custom' combine crew to harvest his wheat crop. If the contract includes a charge for trucking the wheat to some storage point it may be just as economical for the farmer to have the wheat hauled to the elevator. This will be important in determining the amount of storage space needed on the farm.

Another important factor affecting the amount of farm storage is the amount of country elevator space (E) which is available to the farmer. If the farmer can move a large part of his wheat crop into a country elevator at harvest time, the need for farm storage will tend to diminish. This factor can be determined with the greatest accuracy possible by relying upon the past experience of the individual farmer.

The general equation for farm storage is applied to a hypothetical set of figures to illustrate the manner in which it would be used by a farmer to determine the amount of storage space needed.

If it is assumed that a farmer, Mr. X, normally plants 640 acres of wheat, and that he does not plan to use any other crops in the future, but will continue to plant this acreage of wheat. The value of the normal crop (A) can then be determined by multiplying his normal yield by 640, which is the number of acres. If the normal yield is 12 bushels per acre the value of A will be 7680 bushels. Further assume that the amount of carryover (C_2) is 200 bushels. Then the first term of the equation will be (200 + 7680) or 7880 bushels of wheat.

Assume further that he is able to move one-half of the average crop to the country elevator during harvest. This would be equal to the second term of the equation. Thus the second term (H + E) would be 3840 bushels. Substituting the figures in the equation for farm storage we have:

$$O = (C_2 + A) - (H + E), \text{ or}$$

$$O = 7880 - 3840 = 4040 \text{ bushels.}$$

This hypothetical case illustrates the manner in which the storage needs for an individual farm can be determined.

THE EFFECT ON STORAGE REQUIREMENTS OF A CHANGE IN THE VARIABLE FACTORS

The general storage equation and the storage location equations have been presented in detail. It is now time to give some consideration to the variable factors which affect storage volume and storage location. This section is devoted to a study of how such changes can affect the total storage needs as well as the needs at the different storage locations.

Reference to Fig. 1 shows the interaction of the major factors which affect the need for wheat storage. The effects of an assumed change in one of these factors will be traced to determine its ultimate effect on total storage (S) and the effect on any particular storage location. This is done to illustrate the general nature of the equations as developed in the theoretical model. It shows the overall adaptation of the theory to changing conditions.

In order to illustrate the effects of a change in one of the variables, we will assume that an educational campaign to make farmers more aware of quality maintenance has resulted in a definite increase in the quality of the wheat marketed from storage on the farm. All other things being equal, farmers would have less financial risk involved in their farm stored wheat. This would affect farm carryover (C_2), since the farmers may have a tendency to take more of the speculative risks on price changes. The quality maintenance advantages of off-farm storage would be diminished. This would result in an increase in C_2 and a decrease in C_1. Farm carryover (C_2) may also be increased because of declining storage losses on the farm which would increase the amount carried on the farm. In this section we have now assumed that there will be an increase in C_2 and a decrease in C_1 because of the improved farm storage situation.

Let C' be the new total carryover which would result; let C_4 be the increased amount of farm carryover; and C_3 be the lower amount of off-farm carryover. Then if we assume that the increase from C_2 to C_4 is greater than the decrease from C_1 to C_3 the new amount of total carryover (C') is greater than the old total carryover (C).

The effects of the improved farm storage efficiency on the normal crop (A) would be difficult to predict. (See Fig. 1) It could make wheat production relatively more profitable for the farmer, but would not be likely to cause any material increase in the production of wheat since the actual production would be determined by other factors. We may assume, therefore, that there would be no increase in the value of A. Since total carryover is at a new higher level (C') this would mean that the total supply of wheat (Y) would increase by the amount equal to C' minus C. If the new value of Y is Y', then the new equation for total supply of wheat is:

$$Y' = A + C'.$$

The effect of a decrease in C_1 on the terminal equation would mean a net decrease in the amount of terminal storage (T), since there is no reason to expect any increase in the amount of harvest movement (H). (The terminal equation is $T = H + C_1$) There may even be a decline in H as the farmers gain confidence in their ability to maintain quality on the farm. We will assume, however, that the value of H will remain constant in this case. Then if we let T' be the increased volume of terminal storage, and C_3 be the decreased volume of off-farm carryover, the equation will read as follows:

$$T' = C_3 + H.$$

The country elevator storage space (E) will probably remain rather constant since the total annual volume of wheat handled by the elevator would not change. However, there may be a drop in the volume of the harvest rush of marketing. This would allow the country elevator to achieve a better distribution of wheat shipments over the year, and would allow a lower ratio of capacity to annual volume of wheat handled (R). This would increase the opportunity for profit on the investment in storage facilities without decreasing the usefulness of the country elevator.

If we assume that this would happen, then the fractional value of R would decrease, and cause a decrease in the total amount of country elevator capacity needed. Therefore, if we let R' be the new lower figure for R; let the lower elevator capacity be E'; and assume that there is no change in the farm needs for wheat (N); then the country elevator storage equation becomes:

$$E' = R' (A - N).$$

This means that a smaller amount of country elevator capacity will be needed for the same size of wheat crop.

The greatest change would be in the amount of farm storage capacity. The increased size of the farm carryover from C_2 to C_4, and the decrease in country elevator capacity to E' would cause an increase in the total amount of farm storage capacity. Let O' represent the increased amount of farm storage capacity. The equation for farm storage becomes:

$$O' = (C_4 + A) - (H + E').$$

This equation replaces the old one of:

$$O = (C_2 + A) - (H + E).$$

We have found that the assumed change in the storage service (X_5) at the farm caused an increase in total carryover of wheat (C), and a corresponding increase in the total supply of wheat (Y). The terminal storage capacity declined as did the capacity needed at the country elevator. These declines were off-set by an increase in the amount of farm storage capacity used.

This illustration was purposely kept as simple as possible in order to illustrate the way in which the theoretical framework can be used to determine the influence on wheat storage of changes in the variable factors. Many detailed studies of these different variables need to be made in order to determine the magnitude of their effects on wheat storage. When these values are determined more definitely by further research real progress can be made in solving the storage problems of the wheat industry.

SUMMARY AND CONCLUSIONS

This study was undertaken to determine the important factors which affect wheat storage location, and to develop a theoretical model which would show the relationship of these factors. The deductive method of analysis was used to develop this theoretical background for the study.

The total supply of wheat for which permanent storage facilities should be provided will be equal to the normal crop plus a normal carryover.[41] This conclusion is based on the high overhead costs arising when excess storage capacity is maintained in years when wheat production is normal or below. Therefore, it is not profitable to build permanent storage facilities to handle maximum crops.

The total supply of wheat is made up of the annual carryover and the normal crop. The size of these two terms is determined by a combination of physical, psychological, and economic factors which interact in a very complex manner. These factors, which include psychological expectations, government policy, the storage services, production variability, the state of technology, the demand for wheat, and other economic factors, are the independent variables which act to determine the total wheat supply.

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[41] The permanent storage facilities will include some dual-purpose farm storage which is temporarily used for wheat.

The interaction of these variable factors was shown in this study by the use of implicit equations. These equations establish the type of relationship which exists but do not attempt to assign absolute numerical quantities to any of the variable factors. This method is necessary when establishing the general relationship among a large number of unknown factors.

The points at which the supply of wheat can be stored were grouped under three major headings. These are the terminal, the country elevator, and the farm. The final decision on the amount of storage space to be located at each of these points depends primarily upon two fundamental considerations--the variability of wheat production and the ability of the different locations to perform the storage services.

The terminal has definite advantages with respect to production variability and effective performance of the storage services. There is less difficulty from variability because the terminal is located at a greater distance from the production centers and is thus able to draw wheat from a wider area. The terminal has an advantage in performance of the storage services because the larger and more stable volume of wheat handled makes it possible to achieve economies of scale which are not possible at the other storage locations.

The country elevator provides its greatest service by functioning as a concentration point for wheat. If the country elevator is to achieve stability of operation it must limit the amount of storage capacity to that amount which will allow a profitable ratio of annual volume of wheat handled to total storage capacity. The numerical size of the turnover fraction necessary is not known. It will probably vary with local conditions such as the amount of wheat stored by the farmers and the marketing methods of the local farmers.

Farm storage for wheat must be adequate to provide space for the farm needs and all wheat which cannot move into commercial channels at harvest time. The farmers should have permanent space for this portion of the normal crop, and should also be in a position to provide storage for wheat in excess of the normal amount.

The amount of wheat which the transportation system can transport to terminals during the harvest season is one of the important limiting factors on the amount of storage capacity which can be located at the terminals. This is a limitation which should not be considered as fixed since changes are always possible.

The applications of the storage equations which were made in this treatise were used primarily to illustrate their use.

The model of wheat storage economics, and the series of equations which were set up provide a frame of reference to use in determining the wheat storage problems which need further study. It should also be useful in applying the results of past and future empirical studies on the different phases of wheat storage.

The series of equations to determine the supply of wheat to be stored, and the location of this storage capacity, are the tools which were developed to evaluate and apply the material gained from wheat storage research. These equations are the essential portions of this treatise, and are as follows:

Equations for determining total supply of wheat:

(1) $Y = A + C.$

(2) $C = C_1 + C_2.$

(3) $C_1 = f(X_1, X_2, X_3, X_4, X_5).$

(4) $C_2 = f(X_1, X_2, X_3, X_4, X_5, N).$

(5) $A = f(P, F).$

(6) $P = f(V, X_6).$

(7) $F = f(X_1, X_3, X_4, X_7, X_8).$

Equations for determining storage location:

(1) $Y = S.$

(2) $S = T + E + O.$

(3) $T = H + C_1.$

(4) $E = R(A - N).$

(5) $O = (A + C_2) - (H + E).$

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THE ECONOMICS OF GRAIN STORAGE

by

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The purpose of this study is to analyze the economics of grain storage location. The differences in emphasis on storage location which have been expressed in the past indicate that there is need for an overall theory which can be used as a basis for determining storage needs at the different points. This analysis was made to provide a logical framework for making such determinations concerning storage location.

The theory of grain storage location was developed by deductive analysis. The theory was applied to wheat, and a model developed which includes the determination of the variable factors which act to determine the total supply of wheat which should be stored. These factors are presented in a series of implicit equations to establish their relationship to the total supply of wheat.

The supply of wheat for storage was then allocated among three storage locations--terminal, country elevator, and farm. The allocation was made according to the relationship of the three storage locations to the fundamental factors of production variability and the performance of storage services. The relative contributions of the different storage points were determined on the basis of these two factors.

The decision on the portion of the wheat crop which should be stored at each point is also presented in a series of implicit equations. These equations are presented in this form to show the relationships which exist as determined by deduction.

The equations for determining storage needs are presented in two groups. First, those which affect the total supply of wheat are discussed. Second, those which affect the allocation of the supply of wheat for storage among the three storage locations are presented.

Determining the Total Supply

Let Y be the total supply of wheat; let C be the total annual carryover; and let A be the normal crop. Then the equation for the total annual supply of wheat is:[1]

(1) $Y = A + C.$

The total annual carryover (C) is made up of two terms representing different lots of wheat. These are off-farm carryover (C_1) and farm carryover (C_2). Then the equation for the total annual carryover of wheat is:

(2) $C = C_1 + C_2.$

The absolute value of C_1 is dependent upon the following group of independent variables. Let X_1 be the psychological expectations concerning the future; let X_2 be the size of the old crop; let X_3 be the government policy affecting wheat storage; let X_4 be the other economic factors; let X_5 be the storage services; and let f be the functional relationship among the variable factors. Then the equation for off-farm carryover is:

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[1] Imports of wheat into the United States are not included for the following reasons: (1) The United States is usually a net exporter. (2) The United States imports most wheat in seasons when the production peak is past.

$$(3)\quad C_1 = f(X_1,X_2,X_3,X_4,X_5).$$

The absolute value of C_2 is dependent upon the same group of variables as those affecting C_1 with the addition of the farm needs for wheat. Let N be the farm needs for wheat. Then the equation for farm carryover is:

$$(4)\quad C_2 = f(X_1,X_2,X_3,X_4,X_5,N).$$

The normal crop (A) is made up of two terms pepresenting different sets of influences. These are the physical factors (P) and the economic factors (F). Then the equation for the normal crop is:

$$(5)\quad A = f(P,F).$$

The absolute valuo of P is dependont upon two independent variables. Theso are production variability (V) and the effect of technology on wheat production. Let X_6 be the effect of technology. Then the equation for the physical factors acting on the normal crop is:

$$(6)\quad P = f(V,X_6).$$

The absolute value of F is dependent upon many of the same variables which determine C_1 and C_2. These are X_1,X_3, and X_4. There are two other variables which affect the value of F. Those are the inelasticity of production, and the demand for wheat. Let X_7 be the inelasticity of production, and X_8 be the demand for wheat. Then the equation for the economic factors affecting the normal crop is:

$$(7) \quad F = f(X_1, X_3, X_4, X_7, X_8).$$

Required Storage Space

Let S be the total storage space required for wheat. This is equal to the total supply of wheat (Y); hence:

$$(1) \quad Y = S.$$[2]

Let T be the terminal storage capacity; let E be the country elevator capacity; and let O be the farm storage capacity. Then the equation for total storage space required for wheat is:

$$(2) \quad S = T + E + O.$$

Terminal storage capacity is determined by two quantities. One is the harvest movement of wheat to the terminals, and the other is the off-farm carryover of wheat.[3] Let H be this harvest movement of wheat to terminals, and C_1 be the off-farm carryover. Then the equation for terminal capacity is:

$$(3) \quad T = H + C_1.$$

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[2] The value of S includes some farm storage of a dual-purpose nature which is temporary only as far as wheat storage use is concerned.

[3] The value of H may need to include wheat which moves out of temporary farm storage to terminals during the first few months after harvest. This should be considered in the application of the equations to actual conditions. The assumption used here is useful as a first approximation, and is applicable to the available data.

The country elevator storage capacity (E) is determined by three different factors. Let A be the normal crop; let N be the farm needs for wheat which will be used on the farm, and let R be the ratio of total capacity to annual volume of wheat handled. Then the equation for country elevator capacity is:

$$(4) \quad E = R(A - N).$$

Farm storage capacity is determined by four factors which have been defined previously. These are the normal crop (A); the size of the harvest movement to the terminals (H); the amount of the country elevator space (E); and the farm carryover (C_2). Then the equation for farm storage capacity is:

$$(5) \quad O = (A + C_2) - (H + E).$$

The equations listed above are the basis of the storage theory as developed in this treatise. They have been determined by deductive analysis of the relative importance of the various factors which are involved.

In conclusion, the terminal has definite advantages with respect to production variability and effective performance of the storage services. This tends to give the terminal the dominant position when considering storage expansion. The ability of the transportation system to move the wheat to the terminal is a limiting factor on the amount of terminal storage space. The country elevator provides its greatest service by acting as a concentration point for wheat produced by farmers. The amount of country elevator space is limited by the ratio of annual shipments to storage capacity. Farm storage must be adequate to provide space for the farm needs and for all wheat which cannot be moved into commercial channels at harvest.

These are the general limitations on the amount of storage capacity which is necessary at each of the different locations. These limitations are used as a basis for the development of the different equations for storage location and the volume of storage which should be located at these points. The equations which were developed should be useful in carrying on research in wheat storage economics and in applying the results to the whole storage problem.

There is also much existing information which can be applied to the solution of the general problem. Further research is needed to establish the absolute value of many of the terms which were used in the equations. The most important of these are the value of H, R, E, and A.